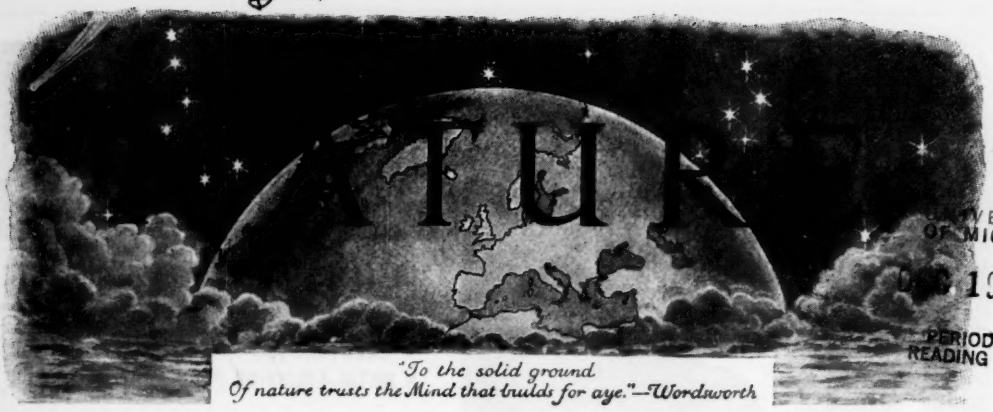
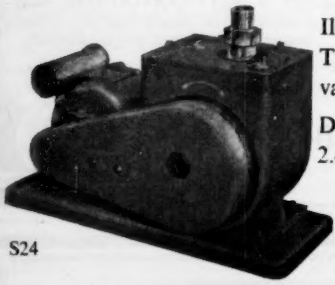
Desk



UNIVERSITY OF MICHIGAN
DEC 10 1956
PERIODICAL READING ROOM

VOL. 178, No. 4544 SATURDAY, DECEMBER 1, 1956 TWO SHILLINGS

METROVAC
ROTARY VACUUM PUMPS



S24

Illustrated is the Type S24 rotary vacuum pump.

Displacement: 2.4 litres/sec.

Please write for details of other models in our range.

METROPOLITAN-VICKERS
ELECTRICAL CO. LTD. TRAFFORD PARK MANCHESTER 17

Member of the A.E.I. group of Companies

OVER THIRTY YEARS EXPERIENCE IN THE HIGH VACUUM FIELD

N/P403

HPQ

VITREOSIL
HIGH PURITY QUARTZ
CRUCIBLES & VESSELS

For Preparation of Hyper-Pure Silicon

Exceedingly low content of boron, aluminium and other elements detrimental to silicon when used for semi-conductors.

THE THERMAL SYNDICATE LTD.
P.O. Box No. 6, Wallsend, Northumberland
Telephone: Wallsend 6-3242.
London: 12-14, Old Pye St., Westminster, S.W.1
Telephone: Abbey 5469.

Humidity Measurement & Control

Hair Element
Wet and Dry Bulb
Gregory Electrolytic

MERCURY-IN-GLASS
MERCURY-IN-STEEL
ELECTRICAL RESISTANCE

Methods

Send for List H/20: Post free

Negretti & Zambra, Ltd., 122 Regent St., W.1 REGent 3406

BRANCHES: *Birmingham · Cardiff · Glasgow · Leeds · Manchester · Nottingham*

AGENTS OVERSEAS: *Argentina · Australia · Belgium · Brazil · Canada · Czechoslovakia · Denmark Egypt · Eire · Finland · France · Greece · Holland · Iceland · India · Italy · New Zealand N. Ireland · Norway · Portugal · S. Africa · Spain · Sweden · Turkey*

Technical Service available in most countries.

'SPEEDIVAC'
VACUUM 'PACKS'

DESIGNED BY MEN FAMILIAR WITH THE CRITICAL DEMANDS OF

• ELECTRONICS • OPTICAL RESEARCH
• METAL-FINISHING • CHEMICAL RESEARCH

1.—at a moment's notice . . . a high-speed pumping, high-vacuum service can be provided for any part of the factory or laboratory.

2.—without involving any "plumbing" or constructional problems.

3.—It is SELF-CONTAINED, incorporating all necessary controls, vacuum measuring and latest valving devices.

For better vacuum service . . .

EDWARDS HIGH VACUUM LTD

MANOR ROYAL · CRAWLEY · SUSSEX CRAWLEY 1500 (10 LINES) EDCOHIVAC CRAWLEY

CASELLA LONDON

TEMPERATURE & HUMIDITY

— at a glance

THE IDEAL INSTRUMENT FOR USE IN OFFICE, STORE ROOM OR FACTORY

This Hair Hygrometer, which enables the relative humidity to be read accurately and quickly, can be fitted with either a Fahrenheit or Centigrade Thermometer.

IMMEDIATE DELIVERY

Price £5 10s. 0d.

For further details write to:

C. F. CASELLA & Co. Ltd.
REGENT HOUSE FITZROY SQUARE
LONDON, W.1
Telephone: ★EUSton 3944

Member Scientific Instrument Manufacturers' Association of Great Britain

NATURE

No. 4544 SATURDAY, DECEMBER 1, 1956 Vol. 178

CONTENTS

	Page
Cost and Price of *Nature*	1199
Chinese Thought and Science. By D. C. Lau	1201
The Physics of Modern Radiology. By Prof. F. W. Spiers	1202
Physics for Non-physicists. By G. R. Noakes	1202
Antibiotics in Agriculture. By Dr. R. Braude	1203
Theoretical Chemistry of Metals. By Prof. N. F. Mott, F.R.S.	1205
Automatic Fundamental Calculations of Molecular Structure. By Dr. S. F. Boys, Dr. G. B. Cook, C. M. Reeves and I. Shavitt	1207
Inheritance of Acquired Characters. By Dr. R. Melville	1210
Obituary :	
Sir Gerald Lenox-Conyngham, F.R.S. By Dr. J. de Graaff-Hunter, C.I.E., F.R.S.	1211
News and Views	1212
Electron Transport in Metals and Solids : Conference in Ottawa. Dr. J. M. Ziman	1216
Gas Turbine Development	1217
Summer School in Physics in the University of Mexico. By Prof. R. E. Peierls, C.B.E., F.R.S.	1218
Myxomatosis in Australia	1219
Dutch–Norwegian Joint Establishment for Nuclear Energy Research : Report for 1954–55	1220
Mechanism of Insect Flight	1220
Enzymic and Chemical Synthesis of the Alpha-1 : 2-Glucosidic Linkage. By Dr. S. A. Barker, Prof. E. J. Bourne, P. M. Grant and Prof. M. Stacey, F.R.S. ; S. Haq and Dr. W. J. Whelan	1221
Cytoplasmic Changes associated with Adaptation and Differentiation. By Pauline G. Briault	1223
Age and Oxidative Phosphorylation in Rat Liver and Brain. By Eugene C. Weinbach and Joel Garbus	1225
Cosmic-Ray Intensity and Geomagnetism. By Profs. Walter Elsasser, E. P. Ney and J. R. Winckler	1226
Letters to the Editors :	
Attenuation of Host Reaction to Ovarian Homografts.—Dr. A. S. Parkes, F.R.S.	1228
Corneal Homografts.—Dr. Paul Bacsich and Prof. George M. Wyburn	1228
Sialoadenectomy and the Metabolism of Calcium-45 in Bone and Soft Tissues of the Mouse.—Arthur W. Wase and Yu Sheng Louise Feng	1229
Some Metabolic Effects of Poliomyelitis Virus on Tissue Culture.—Dr. Hilton B. Levy and Dr. Samuel Baron	1230
Action of the Hypophysis and of Dietary Protein on the Calcifying Tissues.—Prof. J. T. Irving	1231
Synthesis of Phosphocreatine by Enzymes from Heart and Skeletal Muscle.—Osvaldo Cori, Francisco Abarca, René Frenkel and Aida Traverso-Cori	1231
Occurrence of 1 : 2 Dienol Glucose in Normal Blood : its Reaction with Alloxan and Chromatographic Identification.—Prof. M. C. Nath and E. P. M. Bhattathiry	1233
Release of Adrenaline and of Noradrenaline from the Adrenal Gland of the Cat and the Subsequent Resynthesis of these Amines.—Dr. K. R. Butterworth and Dr. Monica Mann	1234
Hereditary Defects of Temperate Bacteriophage.—R. K. Appleyard and J. F. Whitfield	1235
Sodium and Potassium Changes occurring in the Hæmolymph of Insects at the Time of Moulting and their Physiological Consequences.—Dr. G. Hoyle	1236
Change in the Metabolism of Micro-organisms grown on Irradiated Culture Medium.—Prof. A. Krámli, E. Pettkó and M. Sipos	1237
Electrophoretic Evaluation of the Serum Proteins in Malignant Disease.—Dr. R. S. Snell and W. Gross	1238
Intracellular Site of Developing Herpes Virus.—J. V. T. Gostling	1238
Detection by Phenylalanine Tolerance Tests of Heterozygous Carriers of Phenylketonuria.—Dr. David Y.-Y. Hsia, Kathleen W. Driscoll, Walter Troll and Dr. W. Eugene Knox	1239
Seeds of Pure Beta-ray Emitter (Yttrium-90) for Radiation Hypophysectomy.—J. R. Mallard, A. McKinnell and P. E. Francois	1240
Two New Basic Chromosome Numbers in the Genus *Pennisetum*.—M. S. Swaminathan and Joginder Nath	1241
A Mutation to Caracul in the House Mouse.—Maureen MacNeil	1242
A New Mechanism for Amide Hydrolysis.—J. A. Duffy and Dr. J. A. Leisten	1242
Detection by Paper Electrophoresis of the Protein Denaturation in Heat-inactivated Serum for the Complement Fixation Reaction.—Dr. N. M. Larin	1243
A Light Source for locating Œstrogens on Chromatograms.—D. D. Perrin	1244
A New Detector for Vapour Phase Chromatography.—J. Harley and Dr. V. Pretorius	1244
Definition of Chromatography.—S. G. Mokrushin	1244
Cathodic Protection of Iron.—Dr. M. J. Pryor	1245
A Quantity Analogous to Trouton's Constant.—Dr. A. Giacalone	1246
A Function Multiplier.—J. D. N. van Wyk	1247
Liquid Crystals of Montmorillonite.—Dr. W. W. Emerson	1248
Noise Radiation from Tropical Thunderstorms in the Standard Broadcast Band.—S. V. Chandrashekhar Aiya	1249
Temperatures in the Earth's Interior.—Dr. John J. Gilvarry	1249
Guarded-Field Ionization Chambers : a New Principle applied to both Free-Air and Thimble Versions.—Dr. L. A. W. Kemp	1250
Opaque Spherules in Dust collected at Isolated Sites.—Paul W. Hodge	1251
Dried Breadfruit.—F. E. Peters and Pamela A. Wills	1252
"Fluorimetry".—Prof. V. H. Blackman, F.R.S.	1252

CHAPMAN & HALL

Ready this month

INTRODUCTION TO

SOLID STATE PHYSICS

by

Charles Kittel

(Professor of Physics, University of California)

SECOND EDITION

Size: 9¼ in. by 6 in. *617 pages* *Illustrated* *96s. net*

One of the objects of this work is to emphasise those areas of active research in solids which may be discussed in terms of simple physical models. The second edition includes fuller explanations of the basic concepts than did its predecessor, particularly in the areas of crystal symmetry and energy band theory.

STERIC EFFECTS IN ORGANIC CHEMISTRY

Edited by

Melvin S. Newman

WITH TWELVE CONTRIBUTORS

Size: 9¼ in. by 6¼ in. *710 pages* *Illustrated* *100s. net*

This book provides enough data to enable the reader to interpret for himself reactions and phenomena involving a wide range of steric effects. Laboratory workers and theoretical chemists will find in it the first thorough discussion of an area of growing importance in modern organic chemistry.

37 ESSEX STREET, LONDON, W.C.2

PRECISION BS INSTRUMENTS

Pulfrich Refractometer

fitted with circle divided on glass and giving readings on opposite sides of the circle to 5 seconds, by double microscope

This instrument possesses many advantages ove the older type of Pulfrich refractometer and is use in all parts of the world for testing oils, optica glass, chemicals, drugs, etc.

We shall be pleased to demonstrate this instrument and give any advice as to its use, by appointment at our Works.

Bellingham & Stanley Ltd.

DEPT. N, 71 HORNSEY RISE, LONDON, N.1

PHONE: ARCHWAY 2270

COST AND PRICE OF *NATURE*

IT has been decided that at the beginning of 1957 the price of *Nature* is to be raised from 2*s.* to 2*s.* 6*d.* —an increase of 25 per cent. The decision was taken with reluctance, and not without considerable deliberation. Certain obvious economic factors have contributed towards enforcing this step. For example, incredible though it may seem, the great increases in paper and printing charges, especially over the past ten years, and more especially during the past two to three years, have now brought us to the stage when the cost of producing a copy of *Nature* is higher than the price charged. It therefore follows that, with such a journal as this which has no outside financial support or subsidies, those who use it as an advertising medium are its strongest supporters financially, that is, apart from the publishers who, throughout the years, have done everything they can to encourage its growth and development. It is not irrelevant to point out that though in 1957 *Nature* will cost 150 per cent more to the buyer than it did in 1939, the rates charged to the advertisers have been raised much more than that mainly owing, of course, to increased costs of production.

There are few scientists to-day who know that at its inception and for about the thirty ensuing years *Nature* was published at a financial loss—a loss which was sustained entirely by the publishers who then, as now, willingly undertook certain peculiar responsibilities for the advancement of science.

Other journals, both scientific and otherwise, and all newspapers have, since the beginning of the Second World War, found it necessary to increase their prices (in some cases quite drastically). A large number, even during the past two years, have raised their subscriptions from 10 to as much as 50 per cent. In many cases (and this applies especially to newspapers, due mainly to paper rationing) the rise in price has been gradually accompanied by a reduction in the number of pages and consequent amount of text. This has not been the case with *Nature*; in fact, the reverse is true for the amount of text in an issue of *Nature* to-day is well-nigh double that of an issue of 1939 and even more than that of still earlier issues.

In this connexion, Table 1 is of interest. There are set out the total number of pages of text matter appearing in twenty-six issues (equivalent to one volume extending over a period of six months) of the years 1939, 1947, 1955 and 1956. These years are of obvious significance. It will be noted that the actual number of pages in 1947 are less than the corresponding six months in 1939; yet the amount of text in 1947 was much more, for by then there had been an accumulation of war-time economies, such as smaller type, more economic (though essentially less attractive) lay-out, and so forth. These economic measures still hold; therefore, to the figure 1,446 (for 1956) about another 400 pages could justifiably be added for comparison with the figure for 1939. This indicates that in 1956 almost twice as much text is offered per volume as compared with 1939. (We are glad to announce that one war-time economy is to be jettisoned in 1957 in that we shall be returning to the wider page margin though the type-area will remain the same. This will not only add dignity to the journal but also offer a utilitarian advantage to the inveterate note-maker.)

Table 1

Period (June–Nov.; 6 months)	No. of letters and special articles	No. of columns of letters and special articles	Total No. of pages
1939	313	484	1,086
1947	497	644	904
1955	627	1,071	1,194
1956	833	1,323	1,446

Also in Table 1 are indicated the number of actual letters and special articles and the number of columns devoted to these for the same periods covered. The term 'special articles' here applies to those contributions which are really extended research communications in contradistinction to the general articles, reports of scientific meetings, etc., which are not included in Table 1. These special articles are invariably inserted just before the letters (one to four articles per issue).

The distribution of *Nature* is not without interest in this connexion, though it cannot be too strongly emphasized that circulation figures of a journal such as *Nature* are meaningless, at any rate, to the many readers who bear no financial responsibility in connexion with the journal. So widely known and read is *Nature* throughout the world that it is understandable when a person suggests that its *numerical* circulation must be enormous. But this is not the case. The head of one of our leading scientific institutes once said that he and his colleagues had estimated the numerical circulation from various data which he did not at the time disclose. We wish their estimate had been right; but they were 800 per cent out in their calculations. At any rate, the estimate did indicate how much *Nature* is used, if not purchased.

Bound up with distribution is contribution, and Table 2 shows those countries from which letters and

Table 2

Great Britain and Ireland	Belgian Congo
United States of America	Belgium
Australia	Denmark
Canada	Egypt
India, Ceylon and Pakistan	Gold Coast
Japan	Norway
New Zealand	Finland
Czechoslovakia	Kenya
South Africa	Malaya
Sweden	British West Indies
Holland	Nigeria
Hungary	Poland
Italy	Austria
Brazil	Switzerland
Germany (Western)	Uganda
Anglo-Egyptian Sudan	U.S.S.R.
France	Venezuela
Israel	Yugoslavia

special articles were published during the immediate past *six months* (a period corresponding to the 1956 period in Table 1)

The countries in Table 2 are arranged in order of number of communications published from them over the six-month period: for example, United States, 162; Canada, 35; Japan, 17; Czechoslovakia, 12; Hungary, 7; Germany, 7; Israel, 5; Denmark, 4; Egypt, 4; Kenya, 3; U.S.S.R., 1. The complete figures are not given, for they would be misleading, because only a short period is covered. Had this period been extended to, say, one year, more countries would have appeared in the list. In fact, over a longer period it would be seen that most countries throughout the world where scientific research is being carried out use *Nature* for recording and discussing their results.

If time and space allowed comparisons of this (1956) period with similar periods during selected years over the past twenty years, other items of interest would emerge. Table 2 alone, for example, if compared with certain previous years, would stress the great scientific advancement which has taken place in Colonial areas during the post-war years due mainly to government and otherwise sponsored research, and also the commendable efforts being made by the newly established Colonial university and other scientific centres. Moreover, there is an indication that the U.S.S.R. is returning to the fold where she used to play a prominent part before sinking into a period of silence behind the Iron Curtain.

At present, however, we are concerned with Table 2 only so far as it is an indicator of the *geographical* distribution of contributors to *Nature*. This distribution is entirely world-wide, and the same applies to the readers and subscribers, though certainly not numerically; for, by and large, there must be very few working scientists in the world who are unable conveniently to read or refer to any copy of *Nature* they require, no matter whether they be subscribers or not. But geographical distribution is not the same as numerical distribution, in that probably *Nature* is more widely distributed geographically than even some metropolitan daily newspapers. For every issue of *Nature* published there are many more readers. It is fair to emphasize this especially since the advertisers, whose rates have been increased much more than the published price, are in a practical way much stronger supporters of the journal than its readers. There are many and various reasons for this. For example, up to as recently as three years ago, more than two hundred copies of each week's issue of *Nature* were subscribed for from within the U.S.S.R. Then this number was suddenly reduced to about a dozen; yet scientists who have recently visited that country can tell us that they saw photocopies of *Nature* at every scientific centre they visited. Elsewhere, especially in Britain and the United States, it is common to hear quite an active and even outstanding scientific worker state, or maybe even complain, that he is unable to get hold of a copy of *Nature* for ten days to three weeks after it has been published because his colleagues must have their turn first with the one issue for which they subscribe. Comparisons are sometimes misleading, sometimes even odious; but the fact cannot be refuted that at present an issue of *Nature* costs, in Britain, about half the price of a packet of twenty cigarettes and much less than most readers would expect to pay for one seat for one performance at a theatre.

There are, of course, especially among the younger scientists, many who cannot be expected to subscribe personally to a general journal such as *Nature*, particularly those who must, or prefer to, subscribe to other journals. But *all* contributors, whether they be also subscribers or not, and especially authors of special articles and letters, can do much more than they are doing towards keeping the costs of production down. For example, there is still too much rushing into print, and this does not apply solely to the younger enthusiasts. It is sometimes even followed by a request to cancel a contribution which has most probably already cost several pounds sterling in setting of type and maybe even making of blocks for illustrations. Other contributors all too readily make corrections in their proofs—and such corrections are nowadays very expensive to make. For example, it costs about 1*s.* 6*d.* to insert one comma in a proof.

The average weekly authors' corrections, including cancelled matter owing to articles being withdrawn or revised copies submitted after type has been set up, amount to seven columns, or in other words the equivalent of two complete weekly issues is wasted each half-yearly volume (26 *numbers*). *The entire cost of this is borne by the publishers; the time wasted by editors, compositors and readers needs no emphasis.*

In many cases, more care at the initial stages of preparing a manuscript would obviate such expensive corrections. Moreover, corrections are often made in a wasteful and sometimes futile attempt to improve style. The costs of blocks for illustrations also have soared, yet on occasions we are asked to discard a block in favour of a new one. As one editor of *Nature* pointed out in a lecture before the Royal Society of Edinburgh, it would perhaps be a good idea if every contributor to *Nature* asked himself the three following questions before submitting his contribution: (1) Have I said exactly what I want to say? (2) Have I said it in the minimum number of words? (3) Is it worth saying at all? It should here be emphasized that no charge is ever made to authors for corrections or cancellations.

The demand for space in the "Letters to the Editors" section is continually on the increase. By and large, of course, this is a very welcome trend; but contributors are asked to keep their communications down to the absolute minimum in length.

All this is a matter of economics. *Nature* has, geographically and personally, an almost 100 per cent distribution throughout the scientific world, so subscribers are being asked to contribute no more than their fair share of the costs. This share is comparatively, indeed surprisingly, low.

CHINESE THOUGHT AND SCIENCE

Science and Civilization in China

By Dr. Joseph Needham. With the research assistance of Dr. Wang Ling. Vol. 2: History of Scientific Thought. Pp. xxiv+696+plates 14–20. (Cambridge: At the University Press, 1956.) 80*s*. net.

DR. JOSEPH NEEDHAM devotes this second volume of his monumental work to a survey of Chinese thought with an eye to its relevance to science. According to the author, the philosophy of organism together with the Hegelian dialectic is more consonant with modern science than the non-organic philosophy of the past. (Whether this is so or not is a question we can not enter into here.) Further, such a view of the universe can dispense with the notion of a creator by positing a spontaneous inner drive in all things enabling them to develop with a Leibnizian 'pre-established harmony'. Dr. Needham's main thesis in this volume is that Chinese thought, with the exception of certain schools, was of this organic type. From this he concludes that the outlook of the Chinese was scientific, and, in some sense, more scientific than that of their European contemporaries.

It is not clear why this should be so. Philosophically, there is a good deal to be said for the thesis that a view of the universe is a purely metaphysical matter and has no relevance for science. Even if we were to eschew this extreme position, the most we can say is that a metaphysical view may have some practical bearing on science. For example, given the necessary conditions for the development of twentieth century science, a metaphysical view—in this case the philosophy of organism—which is consonant with it may, through suggesting a new point of view, help to bring about this development. On the other hand, this same metaphysical view, coming at a different juncture, might inhibit the original emergence of science. For, in order to arrive at a scientific explanation of any natural phenomenon, it is essential, at least in the early stages of science, to be able to treat a chain of events as isolable. But on the holistic view of Nature, this is impossible, as everything is organically bound up with everything else, and, in order to explain a particular bit of Nature, we would have to concern ourselves with Nature in its totality. Dr. Needham seems, at times, not unaware of this. It is, therefore, puzzling that he should think that the Chinese world view which did not lead to the emergence of science was more scientific than the contemporaneous European view which did give rise to science. Can it be that when Dr. Needham says that a metaphysical view is scientific, what he really means is that it is true? And this, because twentieth century science not only necessarily implies the philosophy of organism but also constitutes the last word in human knowledge? If that were the case, the Chinese should indeed be given credit for arriving independently and without the aid of modern science at a 'true' metaphysical view of the universe.

When one takes a closer look at Dr. Needham's interpretation of Chinese thought, one finds a good deal which leaves room for disagreement.

In his treatment of the early Taoist philosophers, which is one of the least satisfactory parts of the book, he tries to show that they took a scientific interest in Nature. Admitting that they did take a certain interest in Nature, need it necessarily be scientific? Wordsworth, for example, was not necessarily a scientist because he took an interest in Nature. The interest the Taoist philosophers took in Nature was not scientific but philosophical, or, to be more precise, ethical. They were interested, that is to say, only in the lesson implicit in the Way (*tao*) of Nature for man as to how he should lead his life. Here, as elsewhere, Dr. Needham has not sufficiently stressed the central part played by ethics in all Chinese thought.

Again, Dr. Needham produces little evidence for his re-interpretation of the Taoist advocacy of the abolition of knowledge as confined to Confucian scholastic knowledge. There are no good grounds for departing from the generally accepted view that when the Taoist philosophers advised the rulers to "empty the minds of the people and fill their bellies" they meant exactly what they said.

In the section under discussion, one often gets the impression that the evidence Dr. Needham adduces does not quite support his conclusion—an impression that is to return again and again throughout the book.

In the section on "Fundamental Ideas of Chinese Science", one is surprised that although Dr. Needham dismisses the system of the Book of Changes as detrimental to science, he takes a much more favourable view of the Five Elements theory. This is due, perhaps, to his failure to see the full significance of the underlying similarity between the two theories: both exemplify what he calls "correlative thinking". Under each element, as under each *kua* (diagram) of the Book of Changes, is grouped a large number of things. The explanation of any given thing depends on which element it comes under. What makes this kind of explanation so different from the scientific is this: in any situation that requires explanation, there are bound to be a number of factors which most likely come under different elements, and the choice of the significant factor, and with it the element under which it comes, is arbitrary. Thus this system of explanation can never be shown to be unsound, for, whenever an explanation turns out to be false, one can always say that this is because the wrong factor was chosen as significant. Correlative thinking must have constituted one of the major obstacles to the emergence of science, as it was an ingredient to be found in a good deal of Chinese thought.

The section on Neo-Confucianism is probably the most important, as well as the most successful, part of the book. But even here one feels that Dr. Needham has overlooked certain aspects. Neo-Confucianism was both eclectic and 'scriptural'. It accepted as canonical the Confucian Classics—a haphazard collection of works differing widely in origin and point of view. Thus a multiplicity of 'scriptural' sayings, each of which can be used uncritically as authority, have to be accommodated in an uneasy system of thought. Further, according to Dr. Needham, in the Neo-Confucian system morals emerge only when organisms of a sufficiently complex nature appear on the scene. One would have thought that the starting point of the Neo-Confucians was the moral order of human society, and this they took as a pattern for the explanation of the universe. *Li* are principles which are moral as well as natural. If the Neo-Confucian philosophy is to be interpreted as a philosophy of organism, it is misleading to think exclusively of natural organisms. In fact, the Neo-

Confucian vision of the universe was constructed on a moral basis.

In a work of this length, with so many quotations from Chinese works, it is to be expected that one often feels unable to accept the author's translations. But one cannot pass without comment the section on Mohist logic. Dr. Needham has not given sufficient warning to the reader that, in the majority of cases, the text has been so radically and so extensively emended that the translation is of an exceedingly tentative nature. There are, for example, no good grounds for thinking that proposition Cs 14 (p. 179) is concerned with whether evidence is independent of morals, or that Cs 51 (p. 180) approximates to Hegelian dialectical logic.

Incidentally, there are fairly frequent mistakes in the Romanized readings of Chinese characters.

Although I have dwelt mainly on parts of the book which are more open to criticism, I should like to make it quite clear that this is the most significant work in English that has appeared in this field for many a long year. In fact, it is because the book is so full of stimulating ideas that it inevitably provokes disagreement.

D. C. Lau

THE PHYSICS OF MODERN RADIOLOGY

Radiology Physics

An Introductory Course for Radiologists, Radiographers and Medical Students. By Prof. John Kellock Robertson. Third edition. Pp. xvi+329. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1956.) 36*s*. net.

IONIZING radiations, in the form of X-rays and nuclear radiations, have been used in medicine for some sixty years, and lately the scope and intensity of their application have been immensely increased. In this time, however, comparatively few text-books have been available which both present to the student the basic radiation physics and show how it is applied to radiological practice. Among them is Prof. J. K. Robertson's "Radiology Physics", first published in 1940 and now in its third edition. The author has extensively revised the earlier editions and has added much new material. The result is an up-to-date book written to the standard required for an introductory course for radiologists, radiographers and medical students.

The first six chapters cover the subjects of alternating currents, production of high voltage, cathode rays, positive rays and isotopes, Roentgen tubes, rectification and diode and triode valves, discussing broadly the physical phenomena leading to, and underlying, the production of X-rays. The next five chapters describe the physical properties of X-rays and their measurement, including the dosimetry of X-rays in radiotherapy and including also a new chapter on the physical principles of X-ray diagnosis. Of the remaining five chapters, one is devoted to natural radioactivity, one to super-voltage tubes and particle accelerators, two to the transmutation of matter and artificial radioactivity, and the last, a new chapter, to uranium fission and nuclear reactors. Radiation protection is dealt with somewhat briefly in an appendix.

Most of the chapters have been revised and contain new material. The substance of two chapters in the earlier editions has been omitted. There is now no chapter on infra-red, visible and ultra-violet radiations, and the material on high-frequency currents has been reduced to two short sections at the end of Chapter 6. Although the omission of these subjects leaves the book free from material strictly extraneous to radiological physics, I am sorry that they have gone for, hitherto, "Radiology Physics" has been one of the few books to which the medical student could turn for simple relevant information on infra-red and ultra-violet rays and on so-called short-wave therapy. The value of the chapter on dosimetry would have been appreciably enhanced if, in addition to the detailed description of a well-known make of condenser dose meter, more consideration had been given to electronic methods. Extension of the section on valve amplification to include an elementary explanation of the principle of negative feed-back could have led to a discussion of modern dose and dose-rate meters using stable valve amplification.

Prof. Robertson's style is lucid and direct, and physical principles are presented clearly with the necessary mathematical expression where this is required. The many numerical examples worked out in the text are valuable both as an aid to the student's understanding and as a constant reminder that a numerical approach is imperative in the medical use of radiations which must always be regarded as potentially harmful and which possibly can be lethal.

The book is well designed to give the basic understanding of radiation and nuclear physics to the student radiologist. It is perhaps more detailed and more quantitative than is required by the other readers named specifically on the title page; but both radiographers and medical students will find the new edition helpful. Physicists teaching the elements of radiation and nuclear physics to the increasing numbers of those who use ionizing radiations will welcome this book as an aid to their work.

F. W. Spiers

PHYSICS FOR NON-PHYSICISTS

Descriptive College Physics

By Prof. Harvey E. White. Pp. x+485. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1955.) 42*s*.

The World of Atoms

An Introduction to Physical Science. By Prof. J. J. G. McCue, with the assistance of Prof. Kenneth W. Sherk. Pp. xiii+659. (New York: The Ronald Press Company, 1956.) 6.50 dollars.

EXPERIENCE alone can determine whether the needs of a group of non-specialists are better satisfied by a conventional course in physics adjusted to their capacity, or by a more general approach attuned to their outlook; but one would feel that either method, if only it can arouse and hold their interest, can achieve success. These two books, each the work of an enthusiastic and resourceful teacher, seem admirably suited to the needs of the non-scientist students for whom they are intended.

Prof. Harvey White, in selecting material for a short physics course for arts students at the University of California, Los Angeles, appeals to the spectacular experiment and uses very little mathematics. Nevertheless, the elementary mechanics is presented

thoroughly and rigorously, and the reader is led on to the later chapters on atomic and nuclear physics with a good grounding in the conservation laws. There are excellently illustrated chapters on colour and spectra, introducing the important part played by the spectroscopist, particularly in the early days of modern physics. The book is a most valuable interpretation of the experimental side of physics, and manages in this way to make the subject attractive and intelligible to the non-mathematician.

Prof. J. J. G. McCue's book, which is written at the same level for the same type of student, takes a wide survey of the whole of physical science and lays more emphasis on the historical and human aspects. Why do we believe in the existence of atoms and sub-atomic particles, and how do their properties determine those of the materials in the world around us? These are the questions he asks and discusses in seventy-one chapters, each centred on a single topic. The book would probably be harder reading but for the author's foresight in concentrating attention on one thing at a time, pausing at intervals to recapitulate and consolidate the material of several chapters. The chemists' contribution to the history of atomic physics is fully described, as is also the impact of modern physics on theoretical chemistry. The closing chapters have the inevitable good account of nuclear physics, but without the usual dramatic emphasis; rather more space is, in fact, devoted a little earlier to organic chemistry. A catholic selection of suggestions for further reading ranges from original papers to biographies and popular lectures; readers interested in Anderson's first report of the positive electron, Fred Hoyle's views on the origin of the cosmos, or Sir J. J. Thomson's descriptions of baseball and American football, are directed with equal precision to the source. This is a well-written book which, in spite of its wealth of detail, holds the reader's attention to the end.

G. R. Noakes

ANTIBIOTICS IN AGRICULTURE

Proceedings First Conference on the Use of Antibiotics in Agriculture

Pp. xx+278. Publication 397, National Academy of Sciences, National Research Council, Washington 25, D.C., 1956. 2.50 dollars.

IT was an excellent idea of the National Research Council of the U.S. National Academy of Sciences to convene an international Conference on Antibiotics in Agriculture (held during October 19–21, 1955, in Washington, D.C.), and so provide an authoritative forum for discussing the many achievements, problems and expectations in the rapidly growing field of application of antibiotics in agriculture. The publication of the full report on the proceedings of this Conference is the culmination of an enterprise which was well worth while.

The leading experts of the United States and twelve other countries touched in their papers and discussion on every aspect of this fascinating topic. The scope of application of antibiotics is continuously widening. Their usefulness as therapeutic agents and as growth-promoting supplements to feeding-stuffs has been established beyond doubt, and newer developments point ot considerable benefits which may be obtained from application in agronomy (promoting growth and combating infection in plants) and food preservation. Our knowledge and experience in these new fields are still very limited, but the potentialities appear to be enormous.

In 1954 about a quarter of the total production of antibiotics in the United States, namely, nearly half a million pounds, was used as supplements to feeds. All species of agricultural animals appear to have benefited from inclusion of antibiotics in their rations, the magnitude of the positive response depending on many factors. The latter were discussed by many of the contributors.

The mode of action of antibiotics as growth promoters was a subject of a very lively controversy, dominated by the general admission that the available scientific evidence does not allow the exponents of the many hypotheses to be too dogmatic. The exponents of the theme that antibiotics promote growth by virtue of their effect on the bacterial population of the digestive tract discussed the many biological pathways which could lead to an explanation of the phenomenon. The antibiotics could act as prophylactic agents guarding against 'sub-clinical' or obvious infections, or as therapeutic agents in combating disease. They could function by modifying the nutritional requirements of the animals, or by specific effects on some of the essential nutrients. The experimental evidence with germ-free animals was by no means conclusive, and it added an impetus to some of the hypotheses which postulate that the antibacterial properties are not sufficient by themselves to elicit the growth-promoting effect. One of the hypotheses postulated a direct effect of the antibiotic upon intermediate metabolism of the host, others implicated hormonal systems, and still others the possible changes in the metabolic properties of the flora of the digestive tract. One feels rather sympathetic to the view expressed by one of the contributors: "Certainly there is not just one mechanism of action, but several".

The last section of the report deals with the public health aspects involved. In reviewing this part of the proceedings, one cannot do better than quote a paragraph from the summarizing talk of Dr. S. C. Keefer, director of the School of Medicine, Boston University. "It is important to assess the risk of sensitization or of sensitive reactions from antibiotic residues, and also to assess the significance of altering the oral or gastro-intestinal flora, and the emergence of resistant microorganisms as it is related to public health. Certainly the evidence to date would not lead one to believe that the risks outweigh the great benefits which have flowed from the use of antibiotics in animals, to improve nutrition or to prevent or treat diseases, or for that matter from their use as crop sprays in combating plant diseases or in the preservation of food. In any event, this area of antibiotic residues needs continuing study and research, and a fixed and rigid posture should not be taken without a sound basis of evidence. One must weigh the great advantages against the slight risks or the disadvantages."

The report is very well produced and no doubt will serve as a valuable reference book on this very important subject. There are a few mistakes, which could have been avoided by more careful editing, especially of the parts which report the general discussions. The reviewer cannot help feeling that a verbatim report was not the best way of dealing adequately with the discussion.

R. Braude

Gas Chromatography

By Courtenay Phillips. Pp. x+105. (London: Butterworths Scientific Publications; New York: Academic Books, Inc., 1956.) 25*s*.

INTEREST in gas chromatography has become widespread in the few years which have elapsed since the development of gas–liquid partition chromatography by James and Martin, and it is already a major undertaking to read all the papers which have been published in this field. With this book, the first monograph on gas chromatography to appear, Mr. Phillips has done a great deal to lighten the task of anyone intending to make use of gas chromatography. There is a valuable theoretical treatment of the subject, a carefully documented survey of most of the recent work in the field, and a useful list of references.

An important feature of the book is the wide range of techniques discussed. Although there is understandable emphasis on gas–liquid partition chromatography, there is also a section on gas-adsorption chromatography, and the use of gas chromatography in the determination of distribution functions is discussed. The short section in which the uses of adsorption and partition methods are compared might, with advantage, have been expanded; and the inclusion of some practical examples would have been helpful. All the diagrams are clear, and carefully chosen; it would have been very helpful to have included a diagram of the Martin gas-density balance, however, for it is difficult to follow a purely verbal description of this instrument without a picture.

The book is confidently recommended to all who are interested in the applications of gas chromatography.

N. H. Ray

Kant's First Critique

An Appraisal of the Permanent Significance of Kant's Critique of Pure Reason. By H. W. Cassirer. (Muirhead Library of Philosophy.) Pp. 368. (New York: The Macmillan Company, 1954.) 30*s*. net.

THIS book is evidently a very able commentary upon one of the greatest philosophical works of all time. The sub-title is worthy of note, namely, the permanent significance which Kant's masterpiece has for posterity. In the light of his secluded existence at Königsberg and the rigour of his general outlook, it is scarcely to be expected that his successors would find nothing about which to differ. Perhaps to a scientist, the most important point is the justification which the present author finds for the logical dichotomy between the dual aspects of sense-givenness and the impact of the intellect upon what may be presented to it. Kant never thought of them as having a 'really' separate existence. This particular machinery was only introduced in order that some grasp of the nature of perceptual knowledge might follow.

Closely allied to this is the strong case made out by Kant that *a priori* thinking is a pre-requisite for 'knowledge proper'. Dr. Cassirer believes that much is to be gained by an approach of this kind to current problems, rather than by invoking a flood of empiricism. That a fair balance is maintained is illustrated by the writer's rejection of Kant's metaphysical deduction of the categories; but there is probably little need to stress the inacceptable character of his 'supersensible' *Ding-an-sich*, when the mind meets common objects of experience.

F. I. G. Rawlins

The Eighth Plague

By Denys Rhodes. Pp. vii+280. (London and New York: Longmans, Green and Co., Ltd., 1956.) 13*s*. 6*d*. net.

ALTHOUGH described by the author as "essentially a work of fiction", this book includes descriptions of locust swarms and hopper bands, of control operations against them with modern methods and, to a lesser extent, of field research, which must be based on first-hand knowledge, as they are extremely vivid and technically correct. The atmosphere in which this minor war between man and insect is waged in "an anonymous African territory" is effectively conveyed, and the personages —locust control officers, research workers and administrative officials—are very much alive and natural. An applied scientist reading the book will be interested in the attitude of practical field-workers to research workers, which is a mixture of amused contempt and carefully concealed respect. Less clearly brought out is the team-spirit during urgent operations; on such occasions, the author over-stresses individual leadership and makes the personages concerned exhibit heroics out of character. The not unusual conflict between scientists attempting to put their cherished ideas into practice and politicians and administrators who regard a particular approach to a problem mainly in the light of its immediate expediency is well presented. The book deserves attention, as it brings to the notice of a wide public, in a very readable form, a striking example of the kind of human problems arising in the application of science to the development of tropical countries.

Extrasensory Perception

Edited by G. E. W. Wolstenholme and Elaine C. P. Millar. (Ciba Foundation Symposia.) Pp. ix+240. (London: J. and A. Churchill, Ltd., 1956.) 27*s*. 6*d*. net.

THE sceptics are justified in ascribing much of the most interesting evidence in favour of telepathy and clairvoyance to chance; but this explanation cannot be applied to some of the experiments on card guessing, which have given results that would not have occurred by chance even if the whole human race had done nothing but guess cards from the dawn of history to the present day. Well-known statisticians have found no flaw in the calculations and the results present a challenge to scientists. In May 1955 the Ciba Foundation collected a number of people who might be able to explain the facts or suggest the next step. Parapsychology and psychiatry, magic and mathematics, zoology and the basic medical sciences were all well represented at the discussions, which lasted three days and have now been published. The resulting book contains much interesting information, not only about extrasensory perception, but also about bird navigation and the homing of bees. Many marvellous things can be done by conjuring, and some remarkable performances have been shown to be due to the subconscious interpretation of sensory clues; but the experts at this meeting were convinced that there are some things which cannot be explained in such ways. The main impediment to progress in this field is the fact that it is difficult to find percipients who can give statistically significant results, and much time is inevitably wasted on negative experiments.

J. H. Gaddum

THEORETICAL CHEMISTRY OF METALS

By Prof. N. F. MOTT, F.R.S.
Cavendish Laboratory, Cambridge

THE use of electronic computers has made it possible to calculate the electronic wave functions of simple molecules with any degree of accuracy desired. The wave function may be taken as a series of Slater determinants; the one-electron functions contain adjustable parameters which can be found by minimizing the energy. With the increase in the speed of the computers, theoretical chemistry is approaching the point where it can, for example, rival experiment in the determination of the force constants of these molecules.

The study of solids and particularly of metals has not advanced so far. Given unlimited time on the electronic computer, we would not yet know how to set up the wave functions in the form of a series which would converge to the true one as the number of terms increased. There remain unsolved problems in the study of metals, quite apart from those like superconductivity which depend on interaction between the electrons and the lattice vibrations. Even when the nuclei are treated as being at rest, we do not know how to set up an exact wave function. This article is a description of some advances that have been made recently towards a solution of these problems and of some of the difficulties which remain.

Most attempts to set up a wave function for a metal start from the model of Bloch, which is similar to the method of molecular orbitals in chemistry. In this, each electron is treated as moving independently of all the others in a static field due to the nuclei and to the other electrons, the latter averaged in the sense of the Hartree – Fock method. To each wave function is ascribed a wave vector **k**. The determination of these one-electron wave functions is by no means an easy matter, both because of the complicated considerations of symmetry and the labour of setting up the self-consistent field. But there is no difficulty of principle here which cannot be solved, given time and effort, and much progress has been made. The question to be discussed in this article is where we go from there. One needs a wave function to describe the whole system and predict its properties. This wave function in terms of the Bloch model is a single Slater determinant of the one-electron wave functions already described, each with its appropriate spin. However, this is not a very adequate model for quantitative work, neglecting as it does the tendency of electrons of opposite spin to keep away from each other. In early work, particularly that of Wigner[1], a term was introduced into the wave function to describe this tendency, the so-called 'hole' around each electron where another electron would be unlikely to be. More recently Bohm and Pines[2] showed how the size of this hole could be deduced from the existence of co-ordinates describing plasma vibrations in metals.

These methods contrast with that usual in theoretical chemistry and described as configurational interaction. In this one adds further Slater determinants in which some of the one-electron wave functions correspond to excited states, the amplitude of each of these determinants to be determined by minimizing the energy, by perturbation theory or in some other way. This was tried for metals in a well-known paper by Heisenberg[3]; but it is not usually convenient, for the following reason. The concept of the Fermi surface, which follows naturally from the one-electron model, seems to correspond closely to the observed properties of metals; any introduction of excited states destroys the clarity of this concept.

The Fermi surface may be defined as follows in any of the one-electron models, either the single determinant or as modified by Bohm and Pines. Every state of an electron is defined by a wave vector **k** and so is the energy parameter in the one-electron Schrödinger equation. In setting up the Slater determinant which serves as the wave function of the whole system, one uses only the wave functions of occupied states, separated by unoccupied states in **k**-space by a sharp surface of constant energy that we call the Fermi surface. Since such a model must be inadequate in some respects, it is perhaps surprising that there is much experimental evidence that this surface corresponds to some property of the real metal and hence of an exact wave function. Perhaps the most direct are the properties of X-ray emission and absorption bands of light metals. We have to do here with transitions in which electrons in the conduction band made transitions to X-ray levels, or electrons from X-ray levels are excited to states just above the Fermi surface. Both types of spectra show sharp limits in accord with the one-electron theory. This was first shown experimentally by Skinner[4], who in one of his papers also discussed whether interaction between electrons ought to destroy this sharpness of the upper limit, and finds that it should not. His argument is illustrated by Figs. 1 and 2, in which Fig. 1 represents the Fermi distribution of electrons after an absorption process, the electron which has been ejected from an X-ray level being just above the Fermi distribution in the energy-level marked (*a*). Fig. 2 shows the state of affairs after emission of a

Fig. 1

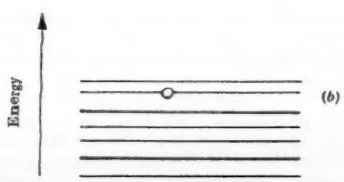


Fig. 2

quantum near the edge, there being a hole in the distribution at (*b*). Skinner shows that both these states will have a long life-time, tending to infinity as the energy interval between (*a*) or (*b*) and the Fermi limit tends to zero. This concept of a very long life-time of a slightly excited electron is confirmed by the most elementary facts about the electrical conductivity of metals; if an electron is set in motion by an electric field, it will at low temperatures in a pure crystalline metal have a very long mean free path, and hence a long life-time in its excited state. This can be terminated by interaction with other electrons, a process not without effect on the electrical resistance (Baber[5]); but the effect tends to zero with temperature and thus with the energy of excitation of the electrons above the Fermi limit.

It thus seems that the exact wave function of the electrons in a metal must have the following properties: it must allow a system of excited states, each carrying a current and with a life-time which tends to infinity as the energy of excitation tends to zero. These states will be described by a wave number **k**, and will be of two classes, as illustrated in Figs. 1 and 2. There will be a sharp dividing surface in **k**-space between the two; this is the Fermi surface.

It is thus extremely convenient to describe a metal by a single Slater determinant, improving the wave function by correlation terms or plasma vibrational co-ordinates and not explicitly introducing wave functions of the excited states which are unoccupied in the one-electron approximation. Such a description gives us a wave function with some of the properties that the exact wave function must have; for example, it retains the concept of a Fermi surface.

The importance of the Fermi surface in the theory of metals lies in the fact that electrons having energies just below it can be excited easily into the unoccupied states above it by thermal fluctuations and electromagnetic fields. Thus these electrons take part in electric, magnetic and thermal processes in metals, so that a determination of the shape of the Fermi surface is basic to any detailed understanding of most of the properties of metals and alloys. In fact, the forces within metals fall into two sharply defined groups. There are the short-range electrostatic and chemical forces, short-range because of the strong screening provided by the conduction electrons, and the effects such as that described above which depend on electrons near the Fermi distribution and can be defined only in relation to large blocks of the crystal. The effects determining crystal structure in many alloys are in the latter class (Jones[6]), though one would guess that the main part of the heat of formation of alloys is in the former.

In the Mond Laboratory in Cambridge two experimental methods are in use of which the interpretation depends on the physical existence of a Fermi surface and by which its form in **k**-space may be determined. These are the anomalous skin effect and the de Haas – van Alphen effect. The de Haas – van Alphen effect consists of the observation at low temperatures of an induced magnetic moment which varies sinusoidally when plotted against the reciprocal of the field. The moment depends on the orientation of the crystal relative to the field. The explanation of the effect in terms of the one-electron model ascribes the fluctuations obtainable with small or moderate fields to 'pockets' of electrons or positive holes, pockets in **k**-space where there is a small overlap into a new zone, or a small unoccupied space at the corner of a zone which is above the Fermi surface. The period of the fluctuations allows the shape of the Fermi surface and the number of carriers to be determined; in some cases it is as low as 10^{-5} per atom. The effective mass can also be determined and is usually low. Experiments are now in progress to study the larger main parts of the Fermi surface by using fields up to 100 kilogauss generated by discharging a bank of condensers through a coil.

That it is physically meaningful in terms of an exact wave function to say that in a given metal 10^{-5} electrons per atom overlap into a given zone is surprising and is not fully understood, though perhaps the explanation will be found along the lines indicated above, depending on the long life-time of excited states. The experiments, however, leave us in no doubt.

The existence and physical reality of pockets of electrons are very useful for the theoretical chemistry of metals. For suppose now that we try to set up the best possible wave function for a metal, starting with a single Slater determinant, using a Hartree – Fock self-consistent model and then taking account of electron correlation in some way. Such a calculation will yield energies of the one-electron states and in particular the energies at the points of particular symmetry in the zones, the corners and the centres of faces. If the de Haas – van Alphen effect shows the existence of small pockets, then these measurements will provide a very sensitive check on the energies of these points. For example, if the metal has a small number of holes and a small number of electrons, then some corner must have energy just above the central point of some face. For metals, therefore, a check on the calculations is available, of a kind not available in molecules or in insulators.

A calculation of this type has recently been carried out in the Cavendish Laboratory for the metal aluminium (Heine[7]), using a self-consistent field, and to determine wave functions by the method of orthogonalized plane waves. The magnetic properties of the metal have been investigated in the Mond Laboratory, and the calculation was undertaken with the view of explaining these properties in detail, locating in **k**-space the 'pockets' responsible for them and obtaining for the first time the detailed electronic band structure of a polyvalent metal. The work was successful in locating these pockets without any ambiguity whatever, though some slight changes in the calculated energy values were, as expected, necessary to fit the facts. The calculations and the experiments between them give a very fair pattern of the whole Fermi surface. They could be repeated for other light metals; for heavy metals the task would be harder.

Some interesting points come out of the calculations. One could ask why one finds pockets containing such an extremely small number of electrons, about 10^{-5}. This could happen if some zone corners had energies exceeding by a very small amount the energy at the centre of some face of another zone; but this would be an accident which should occur rarely, whereas these small pockets seem common. The explanation is that the energies of the one-electron states, except near zone boundaries, are quite surprisingly near the free-electron values ($W = \hbar^2\mathbf{k}^2/2m$). It appears that the effects of the attractive field near each nucleus and of the oscillations of a 3 *s*-wave function are of opposite sign and just balance. The wave functions themselves are very like plane waves, except for these oscillations around each nucleus; this has been recognized already for the alkalis. As a

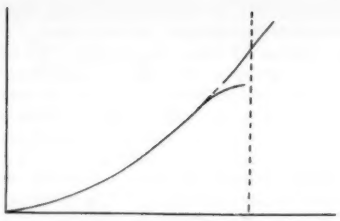


Fig. 3

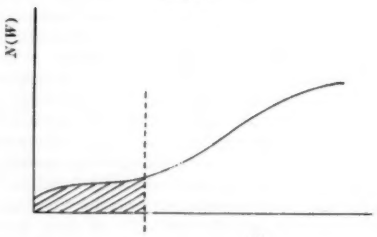


Fig. 4

consequence it has been possible to piece together the reduced Brillouin zones each containing $2N$ states into an extended k-space of the type described by Jones[6] (approximation of nearly free electrons). Since the energies are so close to the value for free electrons, the energy gaps on crossing zone boundaries are small, as shown in Fig. 3, and consequently d^2W/dk^2 is large. This means that the effective mass is small, as shown directly by the experiments, and consequently the density of states is small near one of these points (Fig. 4). This is why the number of electrons in a pocket is so frequently small; it is *not* very sensitive to the position of the Fermi surface, and though it can be changed by alloying another metal which affects the total number of electrons, it is not changed very much.

With the success of work of this kind we may be well on the way to the development of a quantitative theory of metallic properties, with a detailed description of the difference between individual metals. On the other hand, it is still possible that there is something lacking in the present theory, and that the shape of the Fermi surface calculated by refinements of the methods described will not agree with the experiments. Herein lies much of the interest of the work.

[1] Wigner, E. P., *Phys. Rev.*, **46**, 1002 (1934); *Trans. Farad. Soc.*, **34**, 678 (1938).

[2] Bohm, D., and Pines, D., *Phys. Rev.*, **82**, 625 (1951); **85**, 338 (1952); **92**, 609 (1953). See also Pines, D., "Solid State Physics", **1**, 367 (1955).

[3] Heisenberg, W., *Z. Naturforschung*, **2a**, 185 (1947).

[4] Skinner, H. W. B., *Phil. Trans.*, **239**, 95 (1940).

[5] Baber, W. G., *Proc. Roy. Soc.*, A, **158**, 383 (1937).

[6] Jones, H., *Proc. Roy. Soc.*, A, **144**, 225 (1934).

[7] Heine, V., Cambridge Ph.D. thesis (to be published).

AUTOMATIC FUNDAMENTAL CALCULATIONS OF MOLECULAR STRUCTURE

By Dr. S. F. BOYS, Dr. G. B. COOK, C. M. REEVES and I. SHAVITT

Theoretical Chemistry Department, University of Cambridge

IN principle, it is possible to predict the structure and properties of molecules with unlimited accuracy merely from Schrödinger's equation and the numbers and properties of the electrons and nuclei defining the molecule. The complicated mathematical formulation, the very intractable intermediate problems and the extent of the numerical operations have caused this to be both a very confusing and a difficult subject. It does not appear to have been generally realized that the advent of automatic machines has simplified and made practical such calculations, not only as a means for performing the arithmetical operations but also for the carrying out of much of the mathematical analysis of the most formal type. It is hoped that this report and discussion of the results of some prototype calculations of this nature may help to demonstrate the significance and future possibilities of such calculations. The full description will be given elsewhere and will be somewhat lengthy since it will include some theoretical developments which enable the solutions of the formal mathematical problems to be expressed in the form of procedures suitable for automatic performance. However, these are methods applicable to all molecules and, once established, need not be repeated or extended. These methods have been worked out with the facilities of the Mathematical Laboratory, Cambridge, to the director of which, Dr. M. V. Wilkes, and staff we are much indebted. The procedures are in operation on the EDSAC, but could be applied to any general-purpose machine.

The force constants, etc., given below represent the final stages of some fundamental predictions of molecular properties. Their interest does not lie so much in the magnitudes found, as in the fact that they have been obtained using the EDSAC by procedures of the above type which could be applied to any molecule with unlimited accuracy. The machine has been caused to perform most of the organization of the calculations and a considerable portion of the mathematical analysis, as well as all the arithmetic. It is possible, though not certain, that more effort has been required for the development of these procedures than might have been needed for the calculations without automatic computation, but this initial effort is largely non-recurrent.

In Table 1 the force constant and energy were obtained (S. F. B. and G. B. C.) by evaluating the wave functions for the BH radical at three different internuclear distances. The wave functions were obtained as linear combinations of twenty-three co-detors by the variational method. The term co-detor is used

Table 1. Equilibrium Data for BH Radical

	Calculated	Experimental
Total energy	− 25·105	—
Binding energy	0·055	< 0·13
Bond length	2·33	2·33
Force constant	0·30	0·19

for describing antisymmetric functions in many variables which are formed from a set of elementary three-dimensional exponential polynomial functions; first, by constructing orthonormal linear combinations of members of the set; secondly, by using these combinations to form antisymmetric many-dimensional functions of the Slater-determinant type; and thirdly, by constructing simple linear combinations of these determinants which transform as the irreducible representations of the group symmetry of the molecule under consideration. The method of calculation would converge to the true solution of the many-electron Schrödinger equation as the number of the elementary functions is increased and all co-detors corresponding to these are included.

All quantities are expressed in atomic units. The accuracies of the experimental binding energy and force constant are quoted by Herzberg as uncertain.

The EDSAC was used to calculate the numerical values of all the elementary integrals, to perform the various matrix transformations and linear combinations and to solve the eigenvector equation. This would naturally have been expected, but in addition the algebraic formulæ used for a large number of the most complicated integrals had previously been derived by J. L. Turner and S. F. Boys on the EDSAC. In essence, the machine had been caused to manipulate numbers as codes representing mathematical functions and to combine these according to the non-arithmetical processes corresponding exactly to the processes which one performs with the mathematical functions in the determination of an explicit formula for an integral of this type. The largest class of integrals for which this was performed was that of the so-called hybrid six-dimensional electrostatic integrals, some of which led to final formulæ involving more than five hundred terms. This particular application of the machine serves to emphasize the advantages—and, in many cases, the necessity—of handing over to the automatic computer many of those processes of formal mathematics that would generally be regarded as requiring considerable and unavoidable intellectual effort.

Table 2. Equilibrium Data and Force Constants for H_2O

		Calculated	Experimental (ref. 1)
Total energy		− 75·77628	− 76·4641
Binding energy		0·21350	0·3544
O—H distance (R)		1·95	1·85
H—O—H angle		96°	105°
Force constants	A_{11}	1·15	1·07
	A_{12}	− 0·09	+ 0·06
	A_{22}	0·22	0·20
	A_{33}	1·31	1·10

Table 2 shows corresponding data for a subsequent calculation on H_2O (S. F. B. and C. M. R.). This involved the solution of the wave equation at seven nuclear configurations. A total of ninety-six co-detors, formed from eight elementary orbital functions, was examined, but only about thirty of these contributed appreciably to the wave function and were retained for the final parts of the investigation. The total energy of distortion, δE, is given in terms of the O—H distances, r_1 and r_2, and of the H—O—H angle θ radians by:

$$2\delta E = \frac{A_{11}(\delta r_1 + \delta r_2)^2}{4} + 2A_{12}\frac{(\delta r_1 + \delta r_2)(R\delta\theta)}{4} + \frac{A_{22}(R\delta\theta)^2}{4} + \frac{A_{33}(\delta r_1 - \delta r_2)^2}{4}$$

The quantities $(\delta r_1 + \delta r_2)/2$, $R\delta\theta/2$ and $(\delta r_1 - \delta r_2)/2$ are convenient generalized co-ordinates.

In the course of this calculation, the use of the machine for carrying out formal mathematical and essentially non-arithmetical analysis was extended to cover a much greater part of the investigation than in the earlier work. The machine was provided with a list of the co-detors in coded form. It then considered every variational element which could arise and worked out its formula in terms of the single- and two-electron integrals. Previously computed numerical values were substituted automatically into these formulæ and the lowest eigenvalue and corresponding eigenvector of the resulting matrix evaluated to give the required energy and wave function.

It will be realized that after the first decisions have been taken concerning the number and form of the elementary functions, the whole calculation of the wave function, although it appears to involve about half a dozen separate mathematical processes, is in fact a perfectly determinate operation with a unique result which is not dependent on any further decisions. It is the aim of investigations such as these to enable automatic machines to perform the whole sequence of operations with the minimum of intermediate reference to the human investigators. Significant progress has been made towards this goal, although the possibilities of improvements are by no means exhausted.

The comparison of the theoretical and experimental results for the molecular dimensions and force constants (see Table 2) is considered quite satisfactory for the present stage of development. The sign discrepancy in A_{12} corresponds to a relatively smaller discrepancy in the direction of the principal axes of the potential energy quadratic form. In neither calculation were the best sets of elementary functions fully investigated, since the main effort was to put into operation the general calculation procedures, and it was considered that the results for any reasonable parameters would be valuable for future work. The binding energies were found as the difference of the total energies from the calculated energies for the separated atoms. For the comparison with experiment it was desirable to evaluate the force constants; but it should be realized that in this direction the scope of the theoretical method far exceeds the experimental, since it gives directly the energy of distortion to any other configuration, not just the lower derivatives, which are all that can at the present be obtained from spectral analysis.

In the wave function calculation for H_3 (the activated complex of a reaction such as $D + H_2 \rightarrow DH + H$), which led to the values of the 'force constants' given in Table 3, the procedure followed was in principle the same as in the preceding calculations, with the exception of a new particular programme which enabled some complicated integrals to be evaluated about ten times as fast as previously. The whole calculation (by S. F. B. and I. S.) comprised the energy determination for nine different configurations of the nuclei around the transition complex. The activation energy quoted is the excess energy at the 'saddle-point configuration', which was found to be linear, over the calculated energy of a separate hydrogen atom and a hydrogen molecule.

It is valuable to include these results here particularly to emphasize that the type of calculation which we normally call the determination of a

Table 3. Data for the Transition Complex of H_3

		Calculated
Total energy		− 1·628
Activation energy		0·025
H—H distance (R)		1·78
Force constants	A_{11}	0·288
	A_{22}	0·023
	A_{33}	− 0·05

molecular wave function is by no means restricted to the determination for an equilibrium configuration of a stable molecule; it is equally applicable to any configuration of atoms whether these represent a stable molecule, a distorted molecule or an arrangement of atoms in the process of reaction. The force constants in the latter case are, just as in the other cases, the co-efficients of a quadratic approximation to the potential energy in terms of relative nuclear co-ordinates. They cannot, of course, be observed experimentally as physical force constants; but they are necessary theoretical data if a prediction of the reaction-rate is to be made.

Here the total energy of distortion, δE, is given in terms of the H—H distances r_1 and r_2 and of the H—H—H angle θ radians by:

$$2\delta E = \frac{A_{11}(\delta r_1 + \delta r_2)^2}{4} + \frac{A_{22}(R\delta\theta)^2}{4} + \frac{A_{33}(\delta r_1 - \delta r_2)^2}{4}$$

It may be emphasized that although these calculations were made with limited numbers of initial functions (seven for BH, eight for H_2O, six for H_3) and the final convergence is only obtained as these numbers are indefinitely increased, the number of functions in each case was greater than the minimum number which could have been used to give a meaningful result. The procedures would not have required any alteration if larger numbers of such functions were used.

Since the impression seems to be very easily given that the various co-detors used for these calculations correspond to excited states of the system or of some unperturbed system, it may be stated again that this is not so (see Boys[2,3]). Indeed, if functions corresponding, even approximately, to the excited states were used, there would be no ultimate convergence, and the convergence even for small numbers of terms would be very unsatisfactory. This point is illustrated most simply by the fact that the bound-state wave-functions of the hydrogen atom are not a complete system, and that the first few terms are completely unsatisfactory for accurate fitting of functions in the region of the low-energy wave functions. To say, as is sometimes done, that the inclusion of the unbound states would rectify this is not valid, since these do not constitute an enumerable system of functions and so are not applicable to form a complete system of functions in the ordinary mathematical sense, and are even more inconceivable in any practical sense. The situation is that, if the single electron functions are chosen in a manner which would lead ultimately to a complete system of functions (not necessarily orthogonal), then co-detors made from these will also be complete. Direct consideration of this desideratum of completeness, particularly in the physical regions where the wave function is large, is the most effective way which we know at present for obtaining low-energy wave functions (see Boys and Price[4]).

Since the most frequently cited calculations on molecular structure have been by means of the molecular orbital approximation, the relation of this to the present method will be indicated. The molecular orbital approximation signifies in its most exact sense the best approximation to the true wave functions which can be obtained by use of a function of the form of a single Slater determinant, and always retains a definite error. A direct application of this approximation to calculate a wave function involves the evaluation of as many difficult integrals as does the present method, but only obtains a less accurate result. It avoids some of the effort towards the end of the calculations, but this is not a very great economy over the whole calculation. This direct calculation has only been made in four or five cases and then generally with further approximations. On the other hand, the approach which is most frequently described as that of molecular orbitals, and which has been applied very widely, is the use of the approximate formula corresponding to a single determinant in a semi-empirical way in which the quantities on which it depends are not found by calculation, but are adjusted to give the correct answer for some particular molecules, and then these values used to make predictions for other molecules.

The present results must not be regarded as giving the best accuracy which can be obtained with the numbers of expansion functions cited. In fact, most of the effort has been devoted to the development of the general mathematical procedures and to the application of these to give the automatic programmes. In this connexion other workers would probably be interested to know the required machine time. It is very difficult to make any estimate which is not dependent on particular circumstances, but it is probable that, at the present stage of development for a machine obeying a thousand orders per second and having a store of about a thousand words, it would require about forty hours of machine time to produce one wave function for one configuration of the water molecule if a single run without any errors or any checking were possible.

Finally, it may be stressed that the programming of the formal mathematical procedures as well as the associated arithmetical operations offer one of the most stimulating possibilities for the solution of many problems of mathematical physics. This kind of approach appears extremely powerful for problems associated with electronic wave functions, and to have possibilities of even greater value for the complicated problems of nuclear wave functions, particularly for the heavy formalisms of the fractional parentage schemes of functions. On the other hand, the possible application of such methods to the more classical problems, for example, those in which the relaxation methods have been so widely used in desk calculations, should be thoroughly examined. The programming of machines to handle all the theory and arithmetic associated with formal expansions in non-orthogonal complete systems of functions would not be difficult. Such an approach for desk work is difficult owing to the necessary increased strain on the computer working at a higher mathematical level. In an automatic method the increased complication would only enter at the initial stage of making the master programme, and might easily present the more interesting problem.

[1] Heath, D. F., and Linnett, J. W., *Trans. Farad. Soc.*, **44**, 556 (1948).
[2] Boys, S. F., *Proc. Roy. Soc.*, A, **200**, 542 (1950).
[3] Boys, S. F., *Proc. Roy. Soc.*, A, **217**, 235 (1952).
[4] Boys, S. F., and Price, V. E., *Phil. Trans.*, **246**, 451 (1954).

INHERITANCE OF ACQUIRED CHARACTERS

THE problem of the inheritance of acquired characters is one that has exercised the minds of biologists since the days of Lamarck. That interest in this aspect of evolution is unabated was shown by the very full attendance at the joint discussion of the subject, between the Linnean Society and the Systematics Association, held in the rooms of the Linnean Society on November 1. The discussion was opened by Prof. H. Graham Cannon, who cited Leonard Doncaster's definition of an acquired character as "a feature developed during the life of the individual possessing it, in response to the action of use or environment". The added qualification that, "as a rule", such acquired characters were adaptive, has led to much of the trouble arising out of attempts to prove or disprove the proposition. There are two types of experiment, depending on the nature of the change in the environment to which the organism is subjected, whether normal, as occurring in Nature, or not. To the neo-Mendelian the distinction does not matter, for as Carter said, "It is easy to imagine a gene doing anything we want it to do". Every organism in equilibrium with its environment must change somehow if external conditions change. The difficulty is to force it to change obviously, and, as MacBride said, if a change from one environment to another causes a change in structure in one generation, a change in the opposite direction should reverse it in an equal time. This is true of adaptive acquired characters. If the acquired character is induced by some abnormal circumstance, it will be an induced mutation and therefore inherited in the normal Mendelian manner. It seems, therefore, that attempts to demonstrate experimentally the inheritance of acquired characters are a waste of time.

It is Lamarck's fourth law that states explicitly that acquired characters are inherited; but this law is redundant as it is covered by his second and third laws. To Lamarck, it was not a question of a new character appearing in one generation and being handed on to the next. In accordance with his second law, it would appear in any event, because it was required. The present neo-Mendelian theory is based on the idea that, "New hereditary changes occur spontaneously and at random: they are not guided so as to fit the environment". This view was repudiated by Graham Cannon. Mendelian inheritance can go back only as far as the first Metazoa, since it depends on the orderly behaviour of chromosomes. Below that level, there is no true mitosis or meiosis, on which proof of the Mendelian law is based, and, at the best, only *simulacra* of these processes in the Protista. The earliest living matter was an amorphous protoplasm, a chemical mixture in equilibrium with its surroundings and, as such, must have reacted according to the physico-chemical law of Le Chatelier. The result would accord with Lamarck's second law. Protoplasm was able to adjust itself in the optimum manner to changes in its surroundings, and it was unlikely that when cells, sex and chromosomes appeared, this quality disappeared. This homœostatic property of protoplasm applied to the morphology as well as the physiology of the organism. It is the main motive force of evolution.

The problem of inheritance in bacteria was discussed by Dr. A. C. R. Dean. In such micro-organisms, the proportions of enzymes in the cell must attain stable ratios after long-continued growth in a given medium. When the medium is changed, different ratios become necessary and the adjustments are made during the lag phase before growth recommences in the new medium. Considerable growth in the new medium is required, before the ratios settle down again to a new stable value. In bacteria, growth and function are closely linked and response to changes in the environment is automatic. Another interpretation of the lag phase is that it represents the time taken by fully adapted mutants to multiply. Experiments with *Bact. lactis aerogenes* and D-arabinose, designed to test these alternatives, favoured the adaptation hypothesis. Thus, there is an increase of at least 40 per cent in cell mass before cell number increases. No stably adapted strains were obtained by plating out individual bacteria from cultures starting to grow in the new medium. Other tests, with different organisms, indicated that the majority of the cells in a culture undergo adaptation, whether the medium contained a new food material or a drug such as proflavine, streptomycin or chloramphenicol. The stability of an adapted strain depends on how well the training has been impressed on the cells and never seems to become absolute. Even after a thousand generations on drug media, the adaptation, although persisting in some cases for as long as six hundred generations on drug-free media, was eventually lost. The interpretation to be placed on these results is debatable. Dr. Dean inclined to the view that such adaptations represented the development of an existing function, rather than the acquisition of a new one. It is very doubtful to what extent they throw light on the position in multicellular forms.

In attempting to link up the situation in unicellular organisms with that in the higher plants and animals, Dr. R. Melville suggested that the initial changes in the cell were similar in all groups. They depended on the exploitation of existing enzyme systems and alternative metabolic paths. The first result in the higher groups was a phenotypic response, which was not inherited. Environmental changes may set up relentless pressures, and failure to adapt may mean extinction. The probable course of events was that after a variable number of generations, some essential molecule or molecules become attached to a protein molecule, possibly ribose nucleic acid. This may be contained in a cytoplasmic granule and have the properties of a plasmagene. It may pass from cell to cell and be carried over sporadically during fertilization. Afterwards, the plasmagene may be incorporated in a gene and pass into the nuclear mechanism for Mendelian inheritance.

The most critical stage in the suggested adaptive process was probably that leading to the formation of a transmissible particle. As evidence for the occurrence of this process, Waddington's work on the production of pheno-copies for cross-veinless, by

subjecting puparia of *Drosophila melanogaster* to a temperature shock, was cited. Individuals inheriting the character were found from the twelfth generation onwards. In plants, it appeared from Darlington's work on male sterility in *Epilobium luteum* × *hirsutum* that plasmagenes restoring fertility appeared after fourteen generations. From knowledge of the physiology of pollen sterility in *Forsythia* and other plants, boron may be an important factor in the fertility mechanism. This linked up with the mineral content of the soil, as an example of an environmental factor that may exert an adaptation pressure. In discussing temperature, Crosby's paper on the "Role of Plasmogenes in Acquired Adaptations" was mentioned, and it was pointed out that no special assumptions were necessary if the applicability of the Le Chatelier principle were admitted. The effects of temperature were stated more precisely by the van't Hoff principle. It followed, that if a process was controlled partly by exothermic and partly by endothermic reactions, any change of temperature would have a differential effect. Applied to morphology, this could affect the shape of leaves or other organs. An explanation of the topocline in leaf shape in *Ulmus coritana* was possible, on these lines.

In the unavoidable absence of Prof. Waddington, his paper was read by Dr. A. J. Cain, who said that although random mutation and natural selection, together, constitute a mechanism or generating states of high *a priori* improbability, many people were not satisfied that this conventional theory contains the whole truth. The existence of environmentally adapted populations within a species could not be wholly irrelevant to the process of evolution. On general grounds, one would expect the capacity of an organism to respond to environmental stress to be under genetic control. Individuals within a population will vary in this respect and natural selection will favour those in which the response is greatest. Conditions for producing, experimentally, a really adaptive change in an organism had not been devised, but artificial selection could be applied to other environmentally induced responses. When *Drosophila* puparia are subjected to a hot shock, some individuals respond by developing abnormalities in the wing venation. After twelve generations, cross-veinless flies began to appear in untreated individuals. When these were bred together, without further treatment, strains could rapidly be built up, in which nearly all the individuals were cross-veinless. The original phenotypic response was now genetically fixed. Similar results were obtained with populations from different sources. In most wild-type stocks submitted to temperature shock, four types of abnormality occurred. If selection is practised on any one of these, its frequency increases, while that of the others does not. In generalizing from these experiments, it seems possible for a response, that was at first only imperfectly adaptive, to be 'tuned' more closely to the requirements of the animal's life. The mechanism revealed operates in a perfectly 'orthodox' Mendelian way. The most important question remaining for discussion is how it comes about that so many responses of animals to environmental stresses are adaptive. The answer may be based on two considerations. First, that development must be epigenetic, involving interactions between parts, so that, for example, changes in the skeleton are associated with changes in musculature, and *vice versa*; secondly, that selection acting on a macro-evolutionary time-scale will tend to favour types of epigenetic interaction that offer the possibility of adaptive response to stresses.

In the general discussion following, Dr. W. B. Turrill criticized Prof. Graham Cannon for his statements that bacteria had "no nucleus, no chromosomes and no sexuality". Dr. M. L. R. Petterson directed attention to the evidence, published in recent text-books, for the existence of genes in both bacteria and viruses, and Mr. P. F. Mattingly mentioned a very beautiful experimental demonstration by certain French workers of the existence of a linear arrangement of hereditary factors in *Escherichia coli*. Prof. Graham Cannon questioned the validity of work with bacteria kept in culture for considerable periods, and suggested that infection by viruses might affect the results. Dr. Dean admitted that the stocks employed had been in culture some years, but their behaviour was always tested in a standard medium before and after experiments with drugs or alternative carbon sources. Dr. S. M. Manton regretted that the discussion had centred so much around single isolated characters. Many characters are intimately correlated for the harmonious working of a whole animal. For example, the control of movement in a centipede involved nearly all parts of the body, and a change in a single character would be ineffective. The number of simultaneous gene changes necessary to account for tergite heteronomy in the centipedes is so prodigious that the concept needs reconsideration.

R. MELVILLE

OBITUARY

Sir Gerald Lenox-Conyngham, F.R.S.

THE working life of Colonel Sir Gerald Ponsonby Lenox-Conyngham, who was born at Moneymore, Londonderry, on August 21, 1866, the fifth son of Sir William Lenox-Conyngham, and educated at the Edinburgh Academy and the Royal Military Academy, Woolwich, may be reckoned from the time of his being commissioned second lieutenant, Royal Engineers, at the early age of nineteen. Even after his ultimate retirement sixty-two years later, he continued, until his death on October 27, to be the valued counsellor of his friends. The first half of his long career was in India; the remainder in Cambridge. Throughout he was sustained by Lady Lenox-Conyngham, whom he married in 1890. She was daughter of Surgeon-General Sir A. E. Bradshaw, and there was one daughter of the marriage.

An orderly line of progress throughout may be perceived. Lenox-Conyngham joined the Survey of India in 1889 and was then engaged on astronomical field-work for the next dozen years. During 1894–96, as partner to Burrard (later Sir Sidney Burrard), his senior by five years, he was on deputation out of India conducting observations for the precise longitude of India, then embarrassingly in doubt. These two great men—for they were of great stature and of equally notable ability—became and continued fast friends; but they ever remained to each other just 'B' and 'C'.

The longitude at Karachi which they found was closely confirmed thirty years later by observers of the 1926 International Longitude Project, who had manifold advantages of developments such as wireless telegraphy.

Local arrangements for two solar eclipse parties visiting India in 1898 were entrusted to 'C'. At one of the camps he met H. F. Newall, professor of astrophysics at Cambridge, and formed with him a lasting and fruitful friendship. Then came some years of precise latitude field-observations from which deflexions of the vertical—the *direction* of gravity—are derived. 'B' was then seeking the cause of these and previously found deflexions: extra observational evidence, in the form of the force of gravity, was needed.

Thus in 1902 a gravity survey was planned. 'C' was delegated to Europe to examine, acquire and standardize the best available pendulum equipment; and two years later he took to India a set of four brass von Sterneck half-second pendulums. The next few years, during which I was fortunate in being associated with him, saw the beginning of the series of observations which had nearly covered India and Burma before the Second World War. A great difficulty with brass pendulums in field-survey is finding the temperature of the pendulum shaft. 'C' went far to meet this by his 'dummy' pendulum, the shaft of which contained a thermometer. Later he proposed invar pendulums, but was dissuaded by reason of the magnetic susceptibility of invar. Nevertheless, subsequent pendulums have usually been made of invar.

In 1912 he became superintendent of the Trigonometrical Survey. He was an excellent administrator—a firm but sympathetic and trusting chief. Absence of disorder and steady progress of work in hand were apparent in offices where he was in charge, whether field-party or directorate. The onset of the First World War frustrated his natural promotion to surveyor-general; for the services of Sir Sidney Burrard were extended for the duration of the war. Thus Lenox-Conyngham retired as superintendent in 1920, having been elected a Fellow of the Royal Society in 1918 and received the honour of knighthood in 1919.

In 1898 Prof. Newall had had a close view of the then greatest existing practical geodetic organization; and he felt strongly that geodesy, neglected in Britain, should be promoted. So at a well-chosen time he used his great powers in that direction. Only a month ago, at a luncheon given in Trinity College by friends to Sir Gerald and Lady Lenox-Conyngham to mark their attainment of the tenth decade, Sir Gerald made a remarkable speech; and he recounted how after return to England in 1920 he had received a letter from the then Master of Trinity, Sir J. J. Thomson, asking him if he would accept a praelectorship in geodesy coupled with a fellowship of Trinity, and with what satisfaction he assented.

The formation of a School of Geodesy involved especial difficulties for a newcomer to the University; but his charming presence and shrewd sense inevitably prevailed. The School was formed, and later in 1931 was expanded into the Department of Geodesy and Geophysics. Geodetic and topographical surveying became one of the four subjects for the Geographical Tripos, and the School became the training centre for most of those who later became the principal survey officers of the British Colonial Empire. Meantime, the University created a readership in geodesy and appointed Lenox-Conyngham to it, having previously conferred on him the degree of M.A.

During this second career, he attended all the general assemblies of the International Union of Geodesy and Geophysics, from the first at Rome in 1922 to the sixth at Edinburgh in 1936. He also represented H.M.'s Government at the second and third Pacific Science Congresses in Australia in 1923 and Japan in 1926. The inhabitants of Montserrat, Windward Islands, alarmed at the increasing frequency of earthquake shocks, petitioned the Governor to obtain scientific opinion as to their security. So the Council of the Royal Society, consulted by the Colonial Office, invited Lenox-Conyngham to visit the neighbourhood and to investigate the seismic circumstances; this he did in 1936. He gave some account of this in a Friday Evening Discourse at the Royal Institution on March 12, 1937. He also served on the Council of the Royal Society for the periods 1920–21 and 1934–36.

Lenox-Conyngham had become the father of British geodesy. Recently, he received the affectionate greetings and congratulations of the International Association of Geodesy; and his death, inevitable though it be, is a lively sorrow to a wide international circle.

J. de Graaff-Hunter

NEWS and VIEWS

The New Scientist

The interpretation of scientific research and discovery to those who have had no special scientific training and especially to people who have practical interests in the applications and implications of science is now a fundamental need in any country. This need is well met in the United States through *The Scientific American*; somewhat similar journals are published in various countries on the Continent of Europe, and recently one dealing with science for the layman has been launched in India. In this respect, Britain has been backward, although it has several excellent journals of more 'popular' appeal, and frequently newspapers and general popular journals carry excellent interpretative scientific articles. Yet in spite of this there have been repeated calls from industrialists and others, who have realized the need for men and women other than the scientists themselves to understand at least the aims and objectives of research, for a medium which will meet their needs. The very idea, therefore, of such a journal in Britain is welcome, and now it has become manifest in the issue on November 22 of the first number of the weekly periodical, *The New Scientist* (Cromwell House, Fulwood Place, High Holborn, W.C.1).

The aim of this journal is to appeal to all who are interested in scientific discovery and its impact on, and utilization in, industry, commerce and society in general. There are many such people to-day, for the impacts of science are many and profound. It is at last realized that Britain badly needs many more and better trained scientists and technologists; but it can scarcely be expected that such needs will become satisfied or even that the best efforts will be

made to meet them until leaders in industry, commerce, politics and even education itself are better informed concerning things scientific. This can only be done by a journal which is free from scientific technicalities and jargon; and this is the style admirably adopted by *The New Scientist*. For the first issue, the Editor has selected some authors who are not only well known among scientists for their contributions to the advancement of science in various fields but are also able to interpret their work in an intelligible and attractive way to readers who have not been trained in scientific discipline. These authors include the President of the Royal Society (Sir Cyril Hinshelwood), Sir Edward Salisbury, Prof. Zdenek Kopal and Dr. N. A. Mackintosh. There are eight such articles, and each is well worth reading not only by the non-scientist but even by scientists themselves. Apparently we are also to be presented with a series of scientific profiles; Sir Edward Appleton figures in the first issue—an apt choice especially since he is giving the present series of B.B.C. Reith Lectures. Among other features of this excellent first issue are science news from the home front, from the United States and from elsewhere overseas; letters to the Editor; book reviews; and city comment. This last section will appeal particularly to city business men who are specially interested in commercial and industrial projects based directly on scientific discovery.

The New Scientist has made a good start. No doubt it will maintain the high standard which it has clearly set itself, thus becoming a very important and welcome addition to British periodical literature.

Numbers of Science and Technology Students in Britain

Figures for full-time students taking a course for a first degree in science or technology in institutions in receipt of Treasury grant, given by Mr. H. Macmillan in a written reply in the House of Commons on October 23, indicate that in pure science the numbers increased from 5,897 in the academic year 1938–39 to 13,916 in 1951–52 and thereafter declined slightly to 13,485 in 1953–54. In technology the trend was the same: an increase from 3,836 in 1938–39 to 7,590 in 1951–52 and thereafter a decline to 7,439 in 1953–54. The number of first-, second- and third-year students in pure science in 1938–39 was roughly just over 1,800 in each year, and in 1953–54 was again approximately equal—at 4,100–4,300; but the number of fourth-year students, which rose from 396 in 1938–39 to 1,449 in 1951–52, fell to 755 in 1953–54. In technology the variations between the different years became greater: in 1938–39 for first-, second- and third-year students the figures were 1,391, 944 and 1,193, respectively, and in 1953–54, 2,286, 2,240 and 2,031; fourth-year students rose from 276 in 1938–39 to 1,149 in 1951–52, and the number in 1953–54 was 758. Students taking a fifth or later year in technology numbered 32 in 1938–39, 161 in 1952–53, and 126 in 1953–54. An appendix to the ninth annual report of the Advisory Council on Scientific Policy since issued gives the number of first degrees in pure science in 1954–55 as 4,938 compared with 2,167 in 1938, 5,577 in 1951–52, 5,379 in 1952–53 and 5,096 in 1953–54. Of these, 1,886 were pass degrees; and of the honours degrees 914 were in chemistry, 600 in physics, 494 in mathematics, 403 in biological sciences and 122 in geology and related sciences; for 1951–52, the peak year, the corresponding figures are 2,232; 977; 608; 553; 464; and 144, respectively. First degrees in technology in 1954–55 were 2,314, of which 1,005 were pass degrees; for 1938–39 the corresponding figures were 1,048 and 516; for 1951–52, 2,765 and 1,186; for 1952–53, 2,578 and 1,155; and for 1953–54, 2,336 and 1,036.

Patents Bill

In moving the second reading of the Patents Bill in the House of Lords on November 22, Lord Mancroft said that when the Patents Act, 1949, was drafted it was envisaged that, on the restoration of normal peace-time conditions, the Patent Office examiner would make his first report about three months after the complete specification was filed, and that nine months would be a reasonable allowance for the remaining steps to be taken. It was hoped that the arrears of unexamined specifications which had accumulated during the War would soon be cleared, and accordingly the average of the pre-war time limit was adopted and the period made twelve months with an optional further three months on payment of a fee. The intake of patent applications, however, is nearly 40 per cent above the pre-war average of about 21,000, and is still increasing; and with the general shortage of science graduates the Patent Office is unable to recruit enough examiners to keep abreast of the intake. The present examining staff of about 340 (compared with 310 before the War) is expected by special efforts to dispose of nearly 26,000 complete specifications in 1956, leaving an excess of at least 3,500 on the year. There are large arrears of unexamined applications, and it is unusual for the examiner's first report on an application to go out until more than twelve months after the complete specification is filed, leaving no time for the applicant to meet any objections raised by the examiner. The Patent Office is using powers conferred on the Comptroller, under the Emergency Act of 1939, to grant extensions, and the new Bill authorizes the Board of Trade to prescribe from time to time the period during which an application must be put in order for acceptance, subject to the limits that this period must not be less than one or more than four years. The Bill also continues the existing provision of the 1949 Act for allowing the applicant an additional three months on payment of a fee. Replying to questions about staff, Lord Mancroft said that action has been taken to attract graduates and undergraduates to a career in the Patent Office. The salary scale has been revised, and recruits now start at £605, on a scale running up to £1,345, and leading after promotion up to £2,000. Lord Mancroft added in conclusion that it is important not to lower the standard of either the examiners or the patent procedure.

Grants from the R. W. Paul Instrument Fund

The Royal Society announces that grants have been made by the R. W. Paul Instrument Fund Committee as follows: £2,000 to Prof. R. V. Jones and Dr. A. H. S. Holbourn, University of Aberdeen, for continuation of the development of an engine for ruling diffraction gratings in which, in order to avoid the difficulty of making an almost perfect screw, use is made of light waves to determine the grating space; £1,500 to Prof. S. Devons, University of Manchester, for an investigation of the proposed optical system of a new type of reflecting camera incorporating a correcting lens and furnishing increased speed and field of view—a camera which

could be used in an investigation of the structure of weak extended sources of light in interstellar space of the Milky Way. The Paul Instrument Fund Committee, composed of representatives of the Royal Society, the Physical Society, the Institute of Physics and the Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much-improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Early Life of George Boole

Sir Geoffrey Taylor, whose mother was one of George Boole's daughters, contributes to *Notes and Records of the Royal Society*, 12, 1, an article on Boole's early life and mathematical studies. Previous accounts have not always been consistent one with another, nor entirely free from unwarranted speculation. Some interest is attached to these questions, since Boole's work on symbolic logic, first expounded in his "Mathematical Analysis of Logic" (1847) and developed more fully in his "Laws of Thought" (1854), is marked by profound originality of concept; it gave one of the earliest instances of an algebra differing substantially from the familiar algebra of real numbers, and thus not only opened the way to a new field of applications, but also contributed largely to the development of modern ideas on the axiomatic foundations of a variety of abstract algebras. It is possible that this originality was fostered by the resolute manner in which Boole taught himself mathematics, and that the months spent in surmounting difficulties which might have been cleared away in a few minutes by contact with a competent teacher were not entirely a waste of his time, but played a considerable part in forming a powerful and precise research mind. In the same issue of *Notes and Records*, W. Kneale discusses Boole's algebra of logic and its place in the history of mathematical logic.

The Physics and Chemistry of Solids

A new journal, *The Physics and Chemistry of Solids*, has been added to the international series published by the Pergamon Press (London: Pergamon Press, Ltd., 1956. 42*s*. each part. Subscription rates per volume (4 parts): (*A*) £6; 17 dollars); (*B*) for individual subscribers certifying that the journal is for their private use, £2 15*s*.; 7.50 dollars). Prof. Harvey Brooks is editor-in-chief; in his foreword to the first issue, a combined issue for September and October 1956, he defines the fields of physics and chemistry for which the journal is to cater. They are, first, the electronic structure of solids and those physical and chemical properties deriving from that structure; and secondly, the statistical mechanics of condensed systems. Fundamental studies will be preferred to applications; but papers on borderline subjects will, apparently, be welcomed rather than discouraged. The first issue sets a high standard, and the editors, who are drawn from the United States, the U.S.S.R., Holland and France, will secure a prominent position for the journal if they are able to maintain that standard over the years; the advisory board, which includes the names of many whose contributions have greatly helped the advance of the understanding of the solid state, should ensure a steady flow of papers. The topics most to the fore in the first issue are magnetic properties, the absorption spectra of impurities in silicon, energy band-structure and residual resistivity. Two papers in particular contain good reviews of their parts of the subject—a feature which will be frequently required if the editors' aim of developing lines of communication between physicists and chemists is to be fulfilled.

Archæology in India

The October issue of *Man* contains an interesting article by Dr. F. R. Allchin on certain stone alignments in southern Hyderabad. Stone alignments are found at many times and in many parts of the world, and there is not necessarily any reason to suggest cultural connexions between them. In Hyderabad they only occur to the north of the Krishna and Tungabhadra Rivers in the Raichur, Gulbarga, Nalgonda, Mahbubnagar and Atraf-i-Balda districts of the State. They consist of parallel lines of standing stones set out accurately. In all cases the lines seem to be oriented on the cardinal points. It is suggested that their age is late B.C. or early A.D. In the same issue is an interesting article by Prof. Robert Heine-Geldern on the coming of the Aryans and the end of the Harappa civilization in India. It is illustrated with a number of drawings of tools and seals. Prof. Heine-Geldern is convinced that the invaders arrived between 1200 and 1000 B.C., a date somewhat later than that usually suggested and much later than the one indicated in the subsequent (November) number of *Man*. The early archæology of the region from Quetta in Baluchistan right across northern India continues to excite great interest, and some day a firm date for the various cultures found will be finally determined.

Alexander Graham Bell Museum, Nova Scotia

The Alexander Graham Bell Museum, which the Canadian Government has established to illustrate the scientific achievements of the inventor of the telephone, was opened on August 18 at Baddeck, Nova Scotia, where Bell spent his summers for more than thirty years and participated in early aeronautical research. The Museum is sponsored by the Department of Northern Affairs and National Resources, and its purpose is to protect and display the numerous relics of Bell's research that have been given to the Canadian Government. Kites, propellers and other objects indicate the experiments in heavier-than-air flight which Bell carried out between 1896 and 1909, while other material illustrates his investigations in medicine and electrical and marine engineering.

The Industrial Research Associations in Great Britain

The Department of Scientific and Industrial Research has issued an admirably illustrated account of the work of the industrial research associations in the government scheme in a booklet entitled "Combining for Research: the Work of the Industrial Research Associations in the Government Scheme" (pp. 32+16 plates; from the Department, London; 1956). The booklet outlines the nature of the research associations as well as describing the various types of work carried out, and includes brief notes on the individual research associations. While in no way critical, and making no attempt to assess the relative importance or value of the different activities, it indicates very clearly the potentialities of co-operative research as well as the conditions which must be fulfilled for effective work.

United States Awards for Further Study by Science Teachers

THE National Science Foundation, Washington, D.C., is offering a new programme of fellowships for improving the teaching of science, mathematics and engineering in American colleges and universities. About a hundred fellowships will be awarded next March to citizens of the United States who hold a baccalaureate degree or its equivalent, have demonstrated ability and special aptitude for teaching science, have taught full-time at the collegiate level for not less than three years, and who intend to continue teaching. Selection will be based on letters of recommendation, academic records, and other appropriate evidence of professional activity and competence. The value of the fellowships will vary, but the total income must not exceed 10,000 dollars a year; travelling and other expenses will be allowed. Fellows may study for 3–15 months at any accredited non-profit institution of higher education in the United States or abroad. Application must be made before January 14 to the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C., from which further information can be obtained.

University of Hull

IT is announced from the University of Hull that Prof. E. B. Castle, professor of education and director of the Institute of Education, has been appointed pro-vice-chancellor for a period of three years. Dr. Paul Galambos has been appointed lecturer in statistics in the Department of Economics and Commerce. Mr. B. Thomas has been appointed to a research studentship in the Department of Physics for work on radiation damage. The Medical Research Council has made a grant of £600 per annum for a period of three years to assist research work on the biosynthesis of the alkaloids of plants in the Department of Botany under the direction of Dr. B. T. Cromwell; Mr. K. Rothwell has been appointed to a research assistantship in the Department to undertake this work. The Research Section of the Shell Petroleum Company has made a grant of £1,000 to finance a research appointment in the Chemistry Department over a period of two years from the session 1957/58.

University of London

THE following announcements have been made by the University of London: Dr. I. M. P. Dawson, lecturer in pathology in the University of Leeds, has been appointed to the University readership in pathology tenable at Westminster Medical School. The title of reader in physiology has been conferred on Mr. R. D. M. I.-K. Harkness in respect of his post at University College, and that of reader in mathematics on Dr. K. F. Roth, in respect of his post at University College.

Announcements

DR. O. G. S. CRAWFORD, founder and editor since 1927 of *Archæology*, and formerly archæology officer of the Ordnance Survey, has been awarded the *Verdienstkreuz* (first class) of the Federal German Republic, for his services to archæology.

PROF. T. S. WHEELER, professor of chemistry in University College, Dublin, will be going to the United States on a lecture tour during January-March 1957.

MR. GEORGE BREARLEY, a partner of Cremer and Brearley, consulting chemical engineers, and formerly managing director of Brotherton and Co., Ltd., has been appointed director of the Association of British Chemical Manufacturers in succession to Mr. J. Davidson Pratt, who is retiring in June 1957.

THE Ministry of Supply announces that Dr. A. W. Lines has been promoted to deputy chief scientific officer and appointed senior superintendent, Research and Assessment Division, Guided Weapons Department, Royal Aircraft Establishment, Farnborough.

THE following officers and new members of council for 1956–57 of the Institution of Civil Engineers have been announced: *President*, H. J. F. Gourley; *Vice-Presidents*, Sir Arthur Whitaker, Prof. A. J. S. Pippard, A. C. Hartley, Sir Herbert Manzoni; *New Members of Council*, R. J. Ashby, J. F. A. Baker, F. E. P. Clear, D. K. Duff, J. E. Dumbleton, Dr. L. F. Loder, F. J. Oliver and W. L. Owen.

THE Royal Agricultural Society of England offers annually a medal together with an award of one hundred guineas for research work of outstanding merit carried out in the United Kingdom which has proved, or is likely to prove, of benefit to agriculture. Recommendations for the next award, by the heads of university departments, research stations and institutes and other research establishments, must be submitted to the Secretary, Royal Agricultural Society of England, 35 Belgrave Square, London, S.W.1, not later than January 31, 1957.

PROF. V. B. WIGGLESWORTH, Quick professor of biology in the University of Cambridge and director of the Agricultural Research Council Unit of Insect Physiology, will deliver the fourth Middleton Memorial Lecture in the Wellcome Building, 183 Euston Road, London, N.W.1, on December 6, at 5.30 p.m. He will speak on "Insects and the Farmer".

THE Institution of Naval Architects is offering the following scholarships, which are tenable for three or four years, according to the length of the course at the university or college selected: Trewent (naval architecture), £175 per annum; age limit, twenty. Parsons and Yarrow (marine engineering), each £175 per annum; age limit, twenty-one. All three are limited to British subjects. Further particulars can be obtained from the Secretary, Institution of Naval Architects, 10 Upper Belgrave Street, London, S.W.1.

THE autumn meeting of the Physical Society is being held this year in the Department of Natural Philosophy, University of Edinburgh, during December 17–19, and the general theme is "β- and γ-Ray Spectroscopy and Related Topics". During the meeting, on December 18, Prof. P. I. Dee, of the University of Glasgow, will deliver the eighth Rutherford Memorial Lecture of the Society; he will speak on "The α-Particle".

THE first Technical Convention of the Institution of Telecommunication Engineers (New Delhi) will be held on December 30 at the National Institute of Sciences Hall in New Delhi. It will be preceded by the annual general meeting of the Institution on December 29, when Brig. Iyappa, the retiring president, will induct the president-elect, Prof. K. Sreenivasan, head of the Department of Electrical Communication Engineering, Indian Institute of Science, Bangalore.

THE Institution of Chemical Engineers has now moved to 16 Belgrave Square, London, S.W.1.

ELECTRON TRANSPORT IN METALS AND SOLIDS

CONFERENCE IN OTTAWA

An international conference on "Electron Transport in Metals and Solids" was held in Ottawa during September 10–14. The meeting was arranged by Dr. D. K. C. MacDonald, of the National Research Council of Canada, and was supported by the International Union of Pure and Applied Physics, by Unesco, and by the National Research Council. The décor of the meeting—the National Research Council Laboratories, overlooking the wide Ottawa River—was much appreciated by the fifty or so participants. By skilfully rebutting all attempts to include too many persons and too many papers, Dr. MacDonald and his assistants kept the programme within bounds, allowing time for proper consideration of the main topics and discussion of the problems still unsolved. One could wish that all scientific conferences were organized so sensibly, and not made indigestible with a gobble of successive pemmican pellets of condensed yet incoherent discourse.

A full account of the proceedings is to be published as a special number of the *Canadian Journal of Physics*. The following notes summarize (in logical, but not chronological, order) the main subjects.

J. Bardeen opened with a survey of the state of knowledge on interactions between electrons and lattice vibrations, leading to a lively discussion of the causes and effects in the lattice-scattering part of the resistivity of metals. It seems that, with corrections to the Bloch theory, this problem is now understood in principle, but detailed calculations of the resistivity of even simple metals are only now beginning to look reliable. The effects of deviations from equilibrium in the phonon distribution were discussed by E. H. Sondheimer, with reference to recent observations on resistivity and thermoelectric phenomena at low temperatures. G. Borelius pointed out that the resistivity of pure metals at high temperatures can be correlated phenomenologically with other properties; it appears that there may be much to learn from measurements of conductivity of liquid metals. The relation between X-ray scattering and electron scattering by lattice waves was developed by Sir K. S. Krishnan in an ingenious argument.

A review of electrical transport phenomena in alloys, by J. Friedel, brought out the wide variation of behaviour found with various transition elements, both in large and small concentrations, but most of the facts could be correlated reasonably well with theory. More controversial was the discussion concerning the minimum (and sometimes, also, the maximum) in resistance found at low temperatures in metals containing certain impurities. Papers by C. J. Gorter, by R. W. Schmitt and by J. Korringa showed the complexity of the phenomenon and the perplexity of its interpreters. It seems that there may be two distinct mechanisms, one related to an antiferromagnetic ordering in the spins of *d*-electrons in impurities from the transition group of elements and the other, not yet understood, which seems to require some sort of energy-level very near the Fermi surface of the matrix metal.

P. G. Klemens gave an account of the calculation of the electrical resistance due to lattice imperfections in metals. Although some reasonable estimates can be made for the scattering by dislocations, there are still difficulties in explaining the large changes in resistance caused by cold work in metals. An interpretation in terms of scattering by bands of stacking faults was supported by A. Seeger; but in the discussion other speakers found difficulty in believing that this effect could be large.

More fundamental problems concerning the validity of the Boltzmann equation, and the corrections one could make to it, were discussed by I. Prigogine, who outlined recent work on the statistical mechanics of irreversible processes. It is hoped that by starting from the 'master equation', more refined calculations may shortly be possible. Within the framework of the Boltzmann equation, it was shown by J. M. Ziman that there is a close connexion between the thermodynamics of irreversible processes and the variational principle of Kohler, which may be exploited to simplify calculations of transport coefficients. Another variational principle for conduction phenomena in the presence of a magnetic field or asymmetric scattering mechanism was proposed by A. Seeger, and R. Kubo gave a general expression for the conductivity tensor, derived directly from dispersion theory applied to the density matrix.

In reporting measurements on the electrical and thermal conductivity of metals, K. Mendelssohn emphasized the interest of thermal conduction in superconductors, which is effectively pure lattice conduction (although C. J. Gorter pointed out that the two-fluid model could be interpreted in such a way as to lead to an appreciable contribution from a circulation of normal and superfluid electrons). Information from lattice conduction could, as pointed out by P. G. Klemens, supplement electrical measurements in identifying the various types of imperfections in metals. Other experimental data were given by G. K. White, reporting on work in progress at the National Research Council Laboratories.

Nuclear magnetic resonance and the electronic structure of conductors was the subject of a review by N. Bloembergen. It is evident that measurement of the Knight shift yields very diverse information, some of which may be related to band structure or to known transport properties. There seems room for better correlation between this study and measurements of the more traditional transport parameters. On the theoretical side, D. Pines brought up to date the theory of plasmons, showing that in most solids the valence electrons form a plasma the collective oscillations of which have important effects. The calculations are in remarkably good agreement with experiment. It was suggested that, where there are present both holes and electrons, as in a semiconductor, there may be new forms of excitation, having dispersion properties like those of a sound wave; these 'distinct electron modes' may be literally named 'demons'. The various techniques by which direct information can be obtained about the geometry of the Fermi surface were described by R. G. Chambers. Cyclotron resonance, the anomalous skin effect, and the de Haas – van Alphen effect can

all show up anisotropy, and attempts are being made to interpret the results quantitatively.

Although largely devoted to the study of metals, the conference spent some time on topics related to semiconductors. N. F. Mott presented his theory of the transition to metallic conduction in semiconductors, regarding electronic transport in an impurity band as the jumping from site to site with activation by lattice vibrations. P. R. R. Aigrain, on the other hand, preferred a collective picture, in which the randomness of the distribution of impurity sites plays an important part. He suggested that certain states, although not localized, cannot carry current, and hence explained the low mobility in the impurity band. Experimental data on galvanomagnetic effects in *n*-type InSb at 4° K. were given by H. P. R. Frederikse. By considering valence bonds in various compounds, E. Mooser and H. W. B. Pearson were able to present some rules which allow the prediction of semiconducting properties.

An important contribution was made by A. F. Joffé, who discussed recent Russian work on heat conduction in semiconductors. Besides lattice conduction (which may be reduced very effectively by using mixed crystals so that phonons are scattered by the random distribution of atomic mass), there is a significant electronic contribution, and also a further part which may be due to transport of heat by excitons. This led to considerable discussion, with opinions divided as to the exact interpretation.

J. M. Ziman

GAS TURBINE DEVELOPMENT

THE Engineering Department of the North Herts Technical College, Letchworth, arranged a conference on "Gas Turbine Development", which was held during October 20–21. It attracted more than a hundred, most of whom were leading designers or research workers in the appropriate field.

The first of the four main papers was given by Mr. G. B. R. Feilden, engineering director, Messrs. Ruston and Hornsby, Ltd., who offered a brief résumé of the development of the Ruston and Hornsby gas turbine (750/1,000 kW.), since 1946, dealing particularly with the engineering difficulties which were experienced in putting the research designs into working order. At the end of 1,500 hr. running experience with this machine, it was decided to go ahead with a production model capable of 750 kW. and rising to 1,000 kW. maximum output. Improvements were made in the prototype output by raising the maximum temperature, and increasing the length of the turbine blades by 7–8 per cent; production economy being maintained by utilizing tooling for existing blades. It was decided, also, to improve the matching of the components and make minor adjustments to the burners. The completed model had a compressor and turbine practically identical with the prototype, though epicyclic gears had been introduced and the turbine mounting improved. In order to enable the individual components to be serviced easily, however, considerable modifications in layout had been incorporated.

Mr. Feilden illustrated developments in the more recent installations, including one at Milan, which has now been in continuous operation for 10,000 hr. This machine is fired by natural gas, and the arrangement of the combustion chambers with ancillary ducting has proved very practicable for servicing. He also illustrated the installation at Debden, in which the heat exchanger is placed below the set, and the combustion chamber is arranged at an angle downwards. This is a coal-tar fuel-burning set with the ducting arranged upwards. Another slide showed the installation at the Admiralty Test House at Pyecroft, which was made to exacting specifications, the air inlet in this installation being at an unusual angle, and the ducting was woven through the installation. The turbine is to be fitted with a heat exchanger made of corrugated steel plates in the near future.

Mr. Feilden concluded his address by comparing the overall efficiencies of various plants required to produce both power and process steam. The Diesel is the most efficient power producer, and, for a 1,000-kW. electrical output, used in conjunction with an exhaust heat boiler, it gives better figures than any other plant for outputs of process-steam up to 7,500 lb. per hr.; above that requirement, the gas turbine is better. An exclusively steam plant, even with a highly efficient steam turbine and a high-pressure water-tube boiler, is far behind in overall efficiency, and only begins to be competitive if a very considerable quantity of steam (more than 20,000 lb. per hr.) is asked for.

Discussion revealed that problems of servicing under varying climatic and atmospheric conditions have been extremely interesting. While the installation at Kuwait has to digest large quantities of sand, this appears to have no adverse effect upon the turbine blades. The sodium sulphate in airborne particles presents an entirely different problem with the Milan installation, and it is necessary to wash the blades every 200–300 hr. with a solution of 'Teepol' and water; the turbine has now done 3,000 hr. non-stop.

"The Marine Gas Turbine" was the subject of the second paper, by A. W. Pope, chief gas turbine engineer, Messrs. W. Allen, Sons and Co., Ltd. Mr. Pope showed that there are two distinct applications of the marine gas turbine—naval and merchant marine. In connexion with naval applications, there are many differing requirements. Naval can be divided into two categories: (*a*) protection of convoys, and (*b*) task forces. The former duty is performed mainly by frigates, a comparatively new class of ship of which there are various types (fast escort, anti-submarine, anti-aircraft and air direction). The task force duties are undertaken by aircraft carriers and cruisers. The varying requirements mean that aircraft carriers spend much of their time at full power, whereas frigates spend very little. On one such ship, it was found that 70 per cent of full power was used for only 1 per cent of the ship's life. There is here an obvious application for gas turbines (known as boost turbines) to provide the extra power when required. Already two British ships have been provided with such turbines, and an American ship is powered by 9,000 steam h.p., and 21,000 gas turbine h.p., with a saving of 20 per cent on engine weight.

Gas turbines are also being used for electrical generation. There are two types of generator set, namely, emergency and base-load. In emergency sets, fuel consumption is unimportant, and the gas turbine correspondingly simple. Mr. Pope gave an example of the development of such a turbine, detailing various changes in design to give greater efficiency.

Of base-load generator sets, he said that these will undoubtedly become standard practice in the Navy, possessing as they do several advantages over diesel sets, to which they are preferred above 350 kW. Mr. Pope then gave details of a 1,000-kW. base-load generator set and of a 500-kW. set.

On merchant marine applications, Mr. Pope remarked that engines for this purpose operate their whole life at full power, and, due to the cost of running, only one experimental set has so far been built. He gave figures, however, to prove that maintenance costs are much lower than those for diesel engines, and possibly than those of steam turbines. There is, he said, a certain amount of interest in emergency gas turbine generator sets for the merchant marine. One such machine has been developed; it was first run only 21 months after the initiation of the project, and was delivered after only 26 months.

"Air Development" was the theme of an address by Dr. A. W. Morley, head of Forward Projects Investigations Department, Messrs. D. Napier and Sons, Ltd. Dr. Morley traced the development of the gas turbine engine, dating from Dr. A. A. Griffiths (1926), who applied Prof. Frankel's theory of circulation, to the turbo-prop and jet engines which are known to-day. The piston-engine transport, he said, belongs to the past, and he showed a short film of the conversion of the piston-engine transport to the turbo-prop transport (Convair 340). The reasons for the conversion became evident as the lecture developed; namely, it provided a saving of weight and an increase of power, so that the cruising speed went up as well as the pay-load. This conversion utilized the Eland turbo-prop engine, and Dr. Morley justified the title of his lecture by describing in detail the principles and development of the above engine, including the control system, fuel metering system and torque meter. He also dealt with some of its safety aspects, detailing the maximum torquemeter, and overspeed governor, stressing the fact that the ideal design is such that if one part fails something else comes into play.

Dr. Morley then showed how the introduction of new conceptions brings about new machines, as for example in the Fairey Rotodyne (rotor, 90 ft. diameter), Rolls-Royce "Flying Bedstead" and in helicopter development.

Applications to the motor vehicle were dealt with by Dr. J. H. Weaving, chief research engineer, Austin Motor Co., who described the main steps in development, with slides showing the calculations and results represented in graphical form.

The importance of the heat exchanger was emphasized, and it was shown that there is no point in having high compression ratios if a heat exchanger is used. Dr. Weaving compared the efficiencies of the gas turbine with heat exchanger, petrol and diesel engines at full load; it is possible to achieve efficiencies with gas turbines comparable with the diesel engine if a thermal ratio of 0·9 is used, and comparable with the petrol engine if a thermal ratio of 0·7 is used.

Dr. Weaving stated that research is continuing on rigs to improve the efficiency of individual components. A centrifugal compressor has been on test, and axial compressors of single, two and three stages have been tried. A two-stage compressor giving ratios of 4 to 1 and 6 to 1 without overstressing has been used, and a three-stage compressor is now in service. Research into the design of burner and combustion chamber is being carried out by J. Lucas and Co., Ltd.

Dr. Weaving foreshadowed great developments in the regenerative types of heat exchangers, and concluded his address with illustrations of the result of researches in Great Britain, the United States and on the Continent. The installation of the Austin turbine in the "Princess" saloon was shown, also the *G.T.* 302 "Whirlfire" and its novel installation with twin-disk regenerative heat-exchanger as fitted in the General Motors "Firebird".

SUMMER SCHOOL IN PHYSICS IN THE UNIVERSITY OF MEXICO

LAST summer the University of Mexico held, for the first time, a summer school in physics. The subject on this occasion was theoretical nuclear physics, and the course extended from July 9 until the end of August. The twenty-eight members of the school were mostly graduate students or senior staff in theoretical physics, but also included some experimental physicists. Apart from members of the University of Mexico there were visitors from the Argentine (2), Brazil (3), Cuba (1), Britain (1), France (2), Germany (1), India (1) and the United States (9).

Unesco provided for the travelling expenses of some of the members, others had grants from their own national institutions, and in addition a good deal of local expenditure was borne by the University of Mexico.

The meetings, which were conducted in English, were held in the Physics Department of the University (director, Prof. C. Graef Fernandez) and the programme was designed and arranged by Dr. M. Moshinsky, professor of theoretical physics.

The idea of such a summer school bears some relation (and no doubt has received some inspiration) from the successful summer schools that have become regular institutions in Les Houches (France) and Varenna (Italy); but the Mexican Summer School differed from these older institutions by being rather more specialized. The five lecture courses provided all dealt with parts of nuclear theory; their subjects were: collective motions in nuclei (M. Moshinsky); theory of nuclear reactions (R. G. Thomas); electromagnetic reactions with nuclei (J. S. Levinger); the nuclear shell model (B. Stech); and nuclear forces (R. E. Peierls). Thus they covered specialized and well-defined sections of the subject, and with about twenty-four lectures in each course it was possible to present each topic in fair detail. The lectures were given on three mornings and two afternoons each week. In addition, there was a weekly seminar in which the topics ranged rather more widely, and by request of the members of the School a short series of lectures by Prof. Graef Fernandez on general relativity.

One of the obvious functions of such a course was to give some inspiration and encouragement to the young, but growing, group of theoretical research workers at the University of Mexico, and one had the impression that the members of this group appreciated the opportunity of taking part in a live discussion of modern topics from a variety of points of view. They took part in the lectures and discussions with great enthusiasm, in spite of the language difficulty, which must have demanded of some of them as great or greater effort than the

technical difficulties of the subject. The meetings also met with an enthusiastic response from the experimentalists associated with the new nuclear physics laboratory, and both in seminars and outside the lecture rooms there were many occasions when one heard of the fine work done on the Van de Graaff set of the laboratory, and discussed the relations of these results with the theoretical principles that were the main subject of the course.

For the foreign members of the Summer School it was a most stimulating experience to be in Mexico, both because it is always interesting to become acquainted with a new and vigorous research school, and also because they had the chance to see around them so much of beauty and interest. The new University City of Mexico is world-famous for the breath-taking beauty of its buildings and its setting, and there was time enough to see this as a particular example of the achievements of Mexican architecture, which is without comparison in its imaginative use of form and colour, and in the unique way in which it exploits modern building techniques and modern trends, while it remains firmly based on old traditions in art and an impressive sense of continuity of æsthetic values.

For the foreign members there was indeed so much to see outside the Science Institute, and outside Mexico City, that it is a tribute to the programme of the Summer School and to the sense of duty of its members that sight-seeing trips and archæological excursions were normally confined to week-ends or postponed until after the end of the course.

In principle, one might argue that summer schools should not be held in places so attractive as Mexico, and which offer so many alternative interests, or that they should not be held at the sponsoring University, where the local staff have their normal business to attend to. But in this case there was no sign that either of these factors was allowed to divert attention from the activities of the School.

A similar Summer School for 1957 is now under discussion and the subject is likely to be experimental nuclear physics. If the University of Mexico, and the members of the physics staff in particular, are willing to continue to carry the burden involved in the organization of a summer school, and of the generous and friendly hospitality which was provided, the School will undoubtedly establish itself as an important feature in modern physics, which can provide another forum for serious discussion and a focus for the interests of physicists in Latin America.

R. E. Peierls

MYXOMATOSIS IN AUSTRALIA

On September 18 the Commonwealth Scientific and Industrial Research Organization of Australia held a conference in Melbourne to plan the country's myxomatosis campaign for the season.

The conference included representatives of the Organization, the State Departments of Agriculture and of Lands, the Commonwealth Department of Commerce and Agriculture, the Graziers' Federal Council, the Australian Wool and Meat Producers' Federation, the Australian Primary Producers' Union, Commonwealth Serum Laboratories, the Walter and Eliza Hall Institute for Medical Research, and the Australian National University. Sir Ian Clunies Ross was chairman.

Reports from all the Australian States indicated that rabbit populations are extremely low. Myxomatosis has been largely responsible for the reduction in rabbit numbers, but other factors have also contributed; the widespread and organized use of the poison '1080' has been particularly important in Tasmania and Western Australia. Climatic conditions, too, and especially very heavy rainfall, have adversely affected rabbit breeding.

In Tasmania poisoning with '1080' has been most successful. Rabbit numbers have been reduced to an extent which compares favourably with results achieved by myxomatosis in the eastern States.

Prof. F. Fenner, of the Australian National University, reported on his examination of more than 150 strains of myxomatosis virus, including strains from Europe and America.

In Australia, strains of the virus with reduced virulence appeared in the field soon after the initial release of myxomatosis in 1950. These less-virulent strains have become dominant.

In Europe the less-virulent strains did not appear as rapidly but they are now the dominant strains there also.

The conference recommended that further large-scale inoculations with the standard (high-virulence) strain of the virus should be carried out during the coming season to prolong the period of effective use of myxomatosis by allowing fewer rabbits to survive and breed.

If existing low-virulent field strains are allowed to develop without some competition from the standard strain of the disease there will be a much bigger reservoir of survivors to provide genetically resistant progeny.

A high incidence of myxomatosis in the coming spring and summer is predicted. To take maximum advantage of these favourable conditions, a campaign for the general release of the standard (high virulence) strain of the virus has just begun.

Experiments aimed at introducing the 'French' strain of the virus indicated that it did not survive in competition with the existing dominant field strain of low virulence. A warning was given against further introduction of the 'French' strain. It appears that this strain has given rise to much less virulent forms of the virus.

Experiments undertaken by Dr. I. D. Marshall, of the Australian National University, and Dr. W. R. Sobey, of the C.S.I.R.O. Animal Genetics Section, have confirmed that rabbits can inherit some degree of resistance to myxomatosis. Observations in the field have indicated that rabbits are, in fact, inheriting resistance to the disease, but further investigations will be necessary before the degree of this inheritance can be assessed.

The conference was told that it was believed that the European rabbit flea was a major factor in the spread of myxomatosis in the United Kingdom. The Australian Agricultural Council agreed at its meeting in July 1956 to a recommendation that the European rabbit flea be used for myxomatosis experiments in Australia. The conference agreed that such experiments would be valuable, subject to tests to confirm that the flea is harmless to Australian fauna.

The conference urged all landholders to use poison '1080' and all other effective methods after the current myxomatosis season ends. Advantage should be taken of low rabbit numbers to kill off all survivors. The aim must be to eradicate the rabbit from Australia.

DUTCH – NORWEGIAN JOINT ESTABLISHMENT FOR NUCLEAR ENERGY RESEARCH

REPORT FOR 1954–55

THE fourth annual report of the Dutch–Norwegian Joint Establishment for Nuclear Energy Research (J.E.N.E.R.) covers the period from July 1, 1954, to June 30, 1955*, and reports that at Kjeller the natural-uranium heavy-water research reactor, JEEP, has completed its fourth year of operation, yielding 50 MW.-days of heat during the year. A great variety of research work has been done, both in connexion with the design of reactors and of a more fundamental nature, but the principal task of the Establishment is research in the field of nuclear power.

The original design for a pressurized heavy-water reactor, using natural uranium as fuel and heavy water as moderator and coolant, as a power demonstration reactor has been shelved, and instead work has been concentrated on a boiling heavy-water reactor running on slightly enriched uranium and delivering 10 MW. of heat. The Norwegian organization, Institut for Atomenergi (I.F.A.), which together with the Dutch organization, Stichting voor Fundamenteel Onderzoek der Materie (F.O.M.), operates the Joint Establishment, has proposed to the Norwegian Government to build this reactor at Halden, in Norway, 100 km. south of Oslo. The site is on the premises of a paper-pulp plant, Saugbrugsforeiningen, which is interested in the future possibilities of supplying process steam by nuclear reactors, the area being far away from reserves of hydro-electric power. The firm will buy the steam generated in the experiment and will support the project in general. The reactor, except for the control room, will be entirely underground in an artificial cave in the mountainside.

Sales of radioisotopes produced in JEEP increased by 85 per cent more than the previous year. 579 shipments were made, and an additional 262 irradiations were carried out for use within the Establishment. Some radioisotopes, such as labelled compounds and isotopes requiring a high neutron flux which are not easily produced at Kjeller, were imported mainly from the United Kingdom Atomic Energy Authority. The Isotope Department continued its radioisotope service for industry, and a number of new technical applications have been carried out, some of which are briefly described in the annual report.

The neutron diffractometer described in the report for 1953–54 has been improved by the addition of a neutron monitor so that it now gives the number of neutrons scattered by a crystal in a certain direction for a given number of neutrons incident from the reactor, instead of for a given length of time. The angular resolution has also been improved, and a second 'two circle' instrument especially designed for studies of single crystals has been recently put into use. Most of the research work on crystal structures, using neutrons, has been concerned with the determination of 'light' atoms in the presence of 'heavy' atoms, and the substances investigated include CuH, Al_2Th and $Ca(H_2PO_2)_2$. The fission process, the basic process underlying the operation of reactors, has been the subject of experimental and theoretical studies during the year under review, and the angular correlation of fission products, the high-energy gamma radiation from fission fragments and the hazards which might arise from the continuing heat generation from fission products in the event of an accident to a pressurized boiling-water reactor system are some of the topics discussed in the report. A large liquid-scintillation fast-neutron detector, consisting of an aluminium tank, 30 cm. diameter and 30 cm. high, containing an organic scintillator into which cadmium or boron is introduced and viewed by four photomultipliers with 5-in. diameter photocathodes, and a time-of-flight spectrometer have been constructed for studies of fast neutrons.

Work in the Chemistry and Metallurgy Departments has continued on the study of plutonium chemistry and the reprocessing of spent fuel rods, the nuclear properties of uranium oxide fuel rods and full-scale corrosion tests on fuel elements under dynamic conditions. The Health Physics Department has kept constant control of radiation hazards; of the 111 individuals exposed to radiation, not one received a radiation dose greater than half the permissible working dose recommended by the International Commission on Radiological Protection. Five reports and two publications of the Establishment were issued during the year. 300 books, 25 periodicals and 8,500 reports were added to the library, including a technical library consisting of about 6,500 reports (4,900 on microcards), twenty-eight bound volumes of the U.S. Atomic Energy Commission's "National Nuclear Energy Series", a complete set of *Nuclear Science Abstracts* and other material presented by the Commission.

The final sections of the report deal with the accounts of the Establishment for the period under review; the personnel in the various departments; and the various scientific meetings and conferences attended by members of the staff of the Establishment.

* Fourth Annual Report, July 1954–June 1955, of the Dutch–Norwegian Joint Establishment for Nuclear Energy Research. Pp. iii+34. (Kjeller, near Lillestrøm: J.E.N.E.R., 1956.)

MECHANISM OF INSECT FLIGHT

FLIGHT by means of flapping wings demands a higher rate of energy consumption than any other known activity in the animal kingdom. But in no single bird, or bat, or insect has the aerodynamics of the process been closely analysed. Indeed, some authors have claimed that the observed movements of insects would not permit flight in accordance with ordinary aerodynamic principles. This subject is now being studied with all the care it deserves by T. Weis-Fogh and M. Jensen, and their first four papers have been published under the general title of "Biology and Physics of Locust Flight" (*Phil. Trans. Roy. Soc.*, B, **239**, 415; 1956). Dr. Weis-Fogh is an entomologist and physiologist (a student of the late August Krogh, who took an active part in the early stages of the work); Dr. Jensen is an engineer with a special knowledge of the aerodynamics of aircraft. Two of the papers are under joint authorship, and the other two by each author alone.

From a critical review of the available information the authors conclude that natural flight is almost certainly based on conventional aerodynamic principles, even in such small insects as mosquitoes. The energy account of a wing stroke comprises at least three independent terms: an aerodynamic term due

to the wind forces on the wings, an inertial term due to acceleration of the wing mass, and an elastic term caused by the elastic deformations of the thorax. In addition, there may be some extra-muscular damping within the thorax.

In order to analyse how the various wing-stroke parameters are related to the *lift* and the forward *thrust*, the locust was suspended from a complicated balance and flew against a uniform wind the speed of which was automatically adjusted to the point where the thrust was equal to the drag of the body, thus indicating the flying speed. This speed averaged 3·5 m./sec., but might be as much as 4·5–5·0 m./sec. during the first minutes of flight. The power necessary to overcome the drag of the body was only 1–3 per cent of the total metabolic rate; and changes in the inclination of the body up to 20° had no effect at all on the lift, in striking contrast to the effect of pitch on an aircraft. Most of the parameters of the wing stroke are remarkably constant, such as the stroke angles, the stroke plane angles, the middle position of the wings and the time course of the angular movement. Even the stroke frequency showed a maximum increase of 8 per cent during the most active lift. It is therefore concluded that, by analogy with a variable-pitch propeller, the great variations in lift must be caused by differences in *wing twisting*. It is rather remarkable that over the whole range of temperature (25–35° C.) at which flight occurs, the standard wing stroke is completely independent of temperature.

In a detailed analysis of the aerodynamics of locust flight it was found that the calculated vertical lift force, when averaged over an entire wing stroke, equalled the average reduction in body-weight as measured directly on the flight balance. Likewise, the average thrust of the wings as calculated, corresponded with the measured drag of the body. The hind-wings are responsible for about 70 per cent of the total lift and thrust, about 80 per cent of the lift being produced during the down-stroke.

As already noted, the wing stroke of locusts is extremely constant and independent of external conditions. The question arises whether the rhythm is imposed by the central nervous system or peripherally. In the fourth paper of the series, Weis-Fogh discusses some of the sensory mechanisms concerned in locust flight. As is well known, flight can be initiated by the 'tarsal reflex'—sudden removal of contact with the legs; but this causes only about five seconds of flight, or about a hundred wing strokes. Sustained flight is dependent upon the blowing of air over the wind-sensitive hairs on the head. The direction of the air current is immaterial, and, since static bending has no effect, the adequate stimulus is probably minute vibrations of the hairs. A new receptor system is also involved in the maintenance of flight. The adequate stimulus is the rhythmically changing wind-pressure on the wings. The receptors perhaps reside in the wing-hinge, but they have not yet been identified. Finally, in addition to the wing-stroke movements being strikingly constant, there is a very accurate control of the lift; this presupposes a system of lift-sensitive receptors (probably campaniform sensilla at the wing-hinge) which control reflexly the wing-twisting angle.

This important work is still incomplete; six further sections are in preparation.

ENZYMIC AND CHEMICAL SYNTHESIS OF THE ALPHA-1 : 2-GLUCOSIDIC LINKAGE

Enzymic Synthesis

WHEN the dextran-producing organism *Betacoccus arabinosaceous* is grown on a medium containing sucrose and an appropriate second sugar (to serve as an acceptor of transferred glucose units) oligosaccharides are produced in appreciable quantities[1]. A particularly interesting example is the formation of the 'branched' trisaccharide, O-β-D-galactopyranosyl-(1→4)-O-[α-D-glucopyranosyl-(1→2)]-D-glucopyranose, from a mixture of sucrose and lactose[1]. It is now shown that, as was envisaged earlier[1], cellobiose behaves in an analogous fashion to lactose and gives rise to the 'branched' trisaccharide, O-β-D-glucopyranosyl-(1→4)-O-[α-D-glucopyranosyl-(1→2)]-D-glucopyranose. The preliminary chromatographic evidence upon which this work is based was obtained by our former colleague, Dr. R. W. Bailey.

The new trisaccharide was isolated by the charcoal column method[2] from a culture of *Betacoccus arabinosaceous* (Birmingham strain), which had been grown on a medium containing yeast extract, inorganic salts, sucrose (10 per cent) and cellobiose (30 per cent).

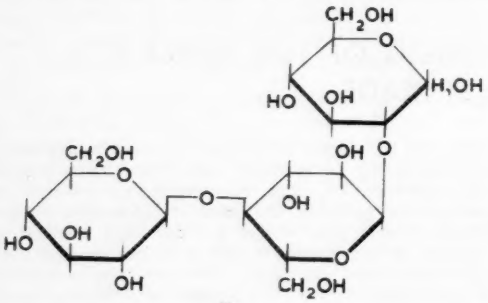
The molecular size was confirmed by oxidation with hypoiodite[3] and by ionophoresis of the benzylamine derivative in formic acid[4]. Acidic hydrolysis gave glucose as the only product detectable by filter-paper chromatography and by ionophoresis in borate (*p*H 10)[5]; partial hydrolysis yielded components corresponding to glucose, cellobiose and a second disaccharide (*Y*). The reducing power of the trisaccharide towards the Shaffer–Hartmann copper reagent[6] was only about 2·5 per cent of that of glucose, a discrepancy which is shown generally by 2-O-substituted glucoses[1]. Moreover, the trisaccharide and disaccharide *Y*, in common with the analogous trisaccharide derived from lactose, were not developed by alkaline triphenyltetrazolium chloride, which detects all reducing glucosaccharides except those with a 2-O-substituent[7]. Further evidence that the reducing unit of the trisaccharide was linked through position 2 was obtained when treatment with phenylhydrazine acetate yielded a mixture of two osazones, similar to cellobiosazone and glucosazone on microscopic examination.

That one of the glycosidic linkages in the trisaccharide was α and the other β was shown (*a*) by its $[\alpha]_D$ value (+93° equil.; conc. 1·00 in water) and also that of the alcohol derived from it (+89° equil.; conc. 1·00 in water), (*b*) by its infra-red absorption spectrum, which displayed a peak at 840 cm.$^{-1}$ (α-linkage) in addition to those given by cellobiose[8], and (*c*) by its conversion to glucose and disaccharide *Y* with almond β-glycosidase.

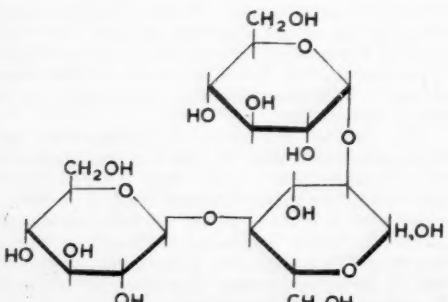
This enzymic hydrolysis proceeded much more slowly than with β-linked disaccharides. The

products were separated on a charcoal–'Celite' column and a sample of disaccharide *Y* was thus obtained. A disaccharide (*X*) was prepared from the lactose-derived trisaccharide in a similar manner. The earlier conclusion[1] that *X* was 2-O-α-D-glucopyranosyl-D-glucose and the above indications that *Y* was identical with it were confirmed (*a*) by paper chromatography and ionophoresis in borate, *p*H 10 [M_G 0·32 (eliminates 1 : 3- and 1 : 6-linkages)[5]], direct comparison eliminated maltose as a possibility; (*b*) by molecular weight determinations using ionophoresis in formic acid and oxidation with hypoiodite; (*c*) by their low reducing power (about 12 per cent of that of glucose) towards the Shaffer–Hartmann reagent (*cf.* sophorose[9]); (*d*) by 96 per cent conversions into glucose with acid; (*e*) by their high $[\alpha]_D$ values (+133° equil.; conc. 0·94 in water); (*f*) by their infra-red absorption spectra, which displayed peaks at 840 cm.$^{-1}$ (α-linkages) but not at 894 cm.$^{-1}$ (β-linkages[8]); (*g*) by their resistance to almond β-glycosidase and (*h*) by the similarity of their stains (aniline hydrogen phthalate spray) with that of sophorose. Direct comparisons with a sample kindly supplied by Dr. Whelan (see following communication) were made by infra-red analysis, paper chromatography, ionophoresis of the benzylamine derivatives and ionophoresis in borate (*p*H 10) and identical results were obtained. Thus *X* and *Y* were both 2-O-α-D-glucopyranosyl-D-glucose (kojibiose[10]).

Two possible structures remained for the cellobiose-derived trisaccharide; these are shown in (I) and (II). The former was considered unlikely when the method of synthesis was taken into consideration and was eliminated also when the sugar consumed 3·90 mol. of periodate with the production of 1·75 mol. of formic acid and no formaldehyde (theoretical value: II, 4, 2, 0) and when its alcohol consumed 5·02 mol. of periodate, giving 1·92 mol. of formic acid and 0·85 mol. of formaldehyde (theoretical values: I, 6, 3, 1 and II, 5, 2, 1). Thus the trisaccharide was O-β-D-glucopyranosyl-(1→4)-O-[α-D-glucopyranosyl-(1→2)]-D-glucopyranose. It is possible that the trisaccharide which was isolated by Buston and Khan[11], following treatment of cellobiose with an extract from *Ch. globosum*, is analogous to our trisaccharide; indeed, these authors noted certain similarities between their trisaccharide and sophorose.



(I)



(II)

We thank Dr. R. W. Bailey for valuable assistance in the preliminary investigations of the trisaccharide.

S. A. Barker
E. J. Bourne*
P. M. Grant
M. Stacey

Chemistry Department,
The University,
Birmingham, 15.

* Present address: Chemistry Department, Royal Holloway College, Englefield Green, Surrey.

[1] Bailey, R. W., Barker, S. A., Bourne, E. J., and Stacey, M., *Nature*, **176**, 1164 (1955) (and earlier references quoted therein).
[2] Whistler, R. L., and Durso, D. F., *J. Amer. Chem. Soc.*, **72**, 677 (1950).
[3] Hirst, E. L., Hough, L., and Jones, J. K. N., *J. Chem. Soc.*, 928 (1949).
[4] Barker, S. A., Bourne, E. J., Grant, P. M., and Stacey, M., *Nature*, **177**, 1125 (1956).
[5] Foster, A. B., *J. Chem. Soc.*, 982 (1953).
[8] Shaffer, P. A., and Hartmann, A. F., *J. Biol. Chem.*, **45**, 377 (1921).
[9] Bell, D. J., "Modern Methods of Plant Analysis", **2**, 9 (1955). Feingold, D. S., Avigad, G., and Hestrin, S., *Biochem. J.*, **64**, 351 (1956).
[8] Barker, S. A., Bourne, E. J., Stephens, R., and Whiffen, D. H., *J. Chem. Soc.*, 3468 (1954).
[9] Rabaté, J., *Bull. Soc. Chim.* (5), **7**, 565 (1940).
[10] Shibasaki, K., *Tohoku J. Agric. Res.*, **7**, 171 (1955) (and earlier refs. quoted therein).
[11] Buston, H. W., and Khan, A. H., *Biochim. Biophys. Acta*, **19**, 564 (1956).

Chemical Synthesis

The formation of 1 : 2-linked polymers of α-D-glucopyranose has been examined as part of our investigations of the chemical synthesis of sugar polymers[1]. The problem had an added interest since the occurrence of the α-1 : 2-glucosidic linkage in Nature has only been recognized very recently and the linkage has not previously been synthesized by chemical methods. The previous communication reports the enzymic synthesis of this linkage, and Shibasaki[2] has described the presence of a diglucose (kojibiose) believed to contain the α-1 : 2-linkage, in a mixture of disaccharides synthesized from glucose by *Schizosaccharomyces pombe*.

The method of synthesis was suggested by the observation[3] that α-glucosides are formed when 1 : 2-anhydro-3 : 4 : 6-tri-O-acetyl-α-D-glucopyranose (Brigl's anhydride[4]) is heated with a suitable molecule containing a hydroxyl receptor group. In this way maltose, sucrose and αα-trehalose were synthesized[3]. It occurred to us that heating the Brigl anhydride alone might cause it to polymerize, with the formation of a polymer of α-1 : 2-linked glucose units. When the anhydride (m.p. 60°) was heated at the temperature of boiling butan-1-ol (b.p. 118°) the initially thin colourless liquid began to darken and thicken during 2–3 days and after a week had set to a hard syrup. Paper chromatographic fractionation of the deacetyl-

ated material revealed glucose and a series of benzidine-reducing oligosaccharides, which had the linear R_M value/DP relationship characteristic of a polymer homologous series[5]. The disaccharide component was isolated. Although it migrated as a single zone on a paper chromatogram it proved to be a mixture of three substances. This was revealed when, after treatment with cold phenylhydrazine acetate, paper chromatography resolved the substance into three zones. Two were coloured yellow (phenylhydrazones); the third, occupying the original position, was due to a non-reducing sugar, identified as αα-trehalose. The two coloured zones were separated and reconverted into the free sugars. The sugar from the faster-moving zone may be a 2 : 2-linked disaccharide; the other has been identified as O-α-D-glucopyranosyl-(1→2)-D-glucose.

The evidence of identification is as follows: (*a*) Acid hydrolysis gave rise to glucose as the only product (paper chromatography). (*b*) Hypoiodite oxidation indicated a disaccharide and confirmed the presence of a reducing group. (*c*) The $[\alpha]_D$ value of +140° (conc. 0·06) suggested the presence of an α-linkage, an inference confirmed by the infra-red absorption peak at 840 cm.$^{-1}$ (α-linkages), but not at 894 cm.$^{-1}$ (β-linkages) (see previous communication). (*d*) The M_G value of 0·32 in borate buffer, *p*H 8·7, shows that the linkage cannot be 1 : 3 or 1 : 6 and the R_F value in butan-1-ol–pyridine–water (3 : 1 : 1) was different from that of maltose (α-1 : 4-link) as well as from nigerose (α-1 : 3) and isomaltose (α-1 : 6). (*e*) Unlike the three last-named disaccharides the new sugar does not react on paper with alkaline triphenyltetrazolium chloride, a property suggestive of substitution at C–2 of the reducing glucose unit[6]. (*f*) Further indication of C–2 substitution is the copper-reducing value of less than 2 per cent as glucose (Somogyi reagent[7]). Sophorose (O-β-D-glucopyranosyl-(1→2)-D-glucose) has the same reducing power. Nigerose, maltose and isomaltose have approximately 50 per cent of the copper-reducing power of glucose. (*g*) Oxidation of the borohydride-reduced disaccharide with a limited amount of sodium metaperiodate (5 molecular proportions) yielded 1·36 mol. prop. of formaldehyde. Treated in the same way, reduced maltose gave 2·20 mol. prop. of formaldehyde.

All these properties are consistent with the assignment of the structure O-α-D-glucopyranosyl-(1→2)-D-glucose to the synthetic disaccharide and confirm the expected manner of polymerization of the Brigl anhydride. The fact that other disaccharides were formed, and, indeed, that disaccharides were formed at all is explicable on the basis of a chain-terminating reaction being caused by traces of moisture. Water should react with the anhydride to form 3 : 4 : 6-tri-O-acetyl-α-D-glucopyranose, which could in turn react with anhydride to yield either αα-trehalose or the α-1 : 2-disaccharide.

As mentioned earlier, the name 'kojibiose' has been applied by Shibasaki and co-workers[2] to a new glucose disaccharide, believed to contain the α-1 : 2-linkage. We are informed by Drs. Shibasaki and Matsuda that they have confirmed its supposed identity. We therefore propose to apply the name kojibiose to the α-1 : 2-linked diglucose.

This work was begun at the University College of North Wales, Bangor, and our thanks are due to Prof. Stanley Peat for his encouragement. We also thank Mr. P. M. Grant for the infra-red data, and Dr. S. Hestrin for information about the triphenyltetrazolium chloride spray.

S. Haq
W. J. Whelan

Lister Institute,
London, S.W.1.

[1] Haq, S., and Whelan, W. J., *J. Chem. Soc.*, 4543 (1956).
[2] Shibasaki, K., *Tohoku J. Agric. Res.*, **6**, 171 (1955) (and earlier refs. mentioned therein).
[3] Lemieux, R. M., *Canad. J. Chem.*, **31**, 949 (1953). Lemieux, R. M., and Huber, G., *J. Amer. Chem. Soc.*, **75**, 4118 (1953). Lemieux, R. M., and Bauer, H. F., *Canad. J. Chem.*, **32**, 340 (1954).
[4] Brigl, P., *Hoppe-Zeyl. Z.*, **122**, 245 (1922).
[5] Whelan, W. J., Bailey, J. M., and Roberts, P. J. P., *J. Chem. Soc.*, 1293 (1953).
[6] Feingold, D. S., Avigad, G., and Hestrin, S., *Biochem. J.*, **64**, 351 (1956).
[7] Somogyi, M., *J. Biol. Chem.*, **160**, 61 (1945).

CYTOPLASMIC CHANGES ASSOCIATED WITH ADAPTATION AND DIFFERENTIATION

By PAULINE G. BRIAULT

Agricultural Research Council Unit of Biometrical Genetics, Department of Genetics, University of Birmingham

RECENT investigations have shown that cytoplasmic changes accompany the growth, differentiation and ageing of homocaryon colonies of a number of species of the *Penicillia* and *Aspergilli*. Variation in the behaviour of colonies derived from single asexual spores of a homocaryon colony has been attributed to the unequal distribution of cytoplasmic elements at spore formation[1,2]. This variation among spores has been used as the basis of selection experiments, by which marked differences in phenotypic behaviour, of purely cytoplasmic origin, have been established.

Induced cytoplasmic changes, obtained by alteration of the medium on which the fungus is grown, have now been investigated in *Aspergillus glaucus*, the cytoplasmic nature of the changes being confirmed by the methods of Jinks[1,2].

Two cytoplasmic changes have been investigated: first, the change induced by transfer from normal medium to medium containing mercuric chloride, and secondly, that induced by transfer to medium in which galactose or xylose had been substituted for the sucrose normally used.

Mass hyphal transfers from normal medium grew on medium containing up to 9 μgm./ml. of mercuric chloride, with no reduction in vigour and at a steady rate, following lag periods of up to fourteen days (during which growth did not occur or was negligible).

Asexual spore transfers from normal medium showed that some of the spores, but only a small proportion, were also capable of growth on mercuric chloride medium, after varying lag periods. No spores were capable of growth on concentrations

exceeding 3 μgm. mercuric chloride/ml. Spores of a uniform age from any one colony were found to be markedly heterogeneous for the level of poison on which they were capable of growing.

Hyphal transfers from adapted colonies (that is, colonies growing on the mercuric chloride medium) to mercuric chloride medium grew with no significant lag.

The behaviour of the asexual spores from adapted colonies on the mercuric chloride medium was, on the other hand, very little different from that of the spores from an unadapted colony. Spores from adapted colonies showed the same heterogeneity in concentration of poison tolerated and in lag period of survivors on any one concentration as did spores from unadapted colonies. As with spores from unadapted colonies, concentrations greater than 3 μgm. mercuric chloride/ml. were completely toxic.

Table 1 gives the distribution of toleration of various levels of mercuric chloride in a sample of asexual spores from a colony on 5 μgm./ml. mercuric chloride. The variation in age among the spores of the sample was less than 48 hr. The cytoplasmic heterogeneity is thus almost entirely due to unequal distribution of cytoplasmic elements at spore formation, the effect of mycelial and spore ageing being very small.

Table 1

Level of mercuric chloride	Percentage of spores in random sample
0·0–0·5 μgm./ml.	3·4
0·5–1·0 „	1·8
1·0–2·0 „	83·6
2·0–3·0 „	9·5
3·0 „	1·7

Only on concentrations just below toxic, that is, about 3 μgm./ml., was there a significant difference in the behaviour of spores from adapted and unadapted colonies on the mercuric chloride medium. On these sub-toxic concentrations, spores from adapted colonies of most lines gave a higher percentage survival, and a shorter mean lag period of the survivors, than spores from unadapted colonies. This difference is illustrated in Table 2.

Table 2

Homocaryon line	Percentage survival of spores From unadapted colony	From adapted colony	Difference in mean lag period
1_1	4·4	7·8	22 hr.
1_3	2·2	20·2	150 hr.
1_4	0·0	0·0	0 hr.
2	4·6	25·1	42 hr.

When the behaviour of mass hyphal transfers on the galactose and xylose media was investigated, growth was found to start after a lag period of a few days, during which little or no growth occurred.

Samples of asexual spores of uniform age, from different homocaryons raised on sucrose, when plated on to sucrose, xylose and galactose, showed significant variation in ability to grow, both between homocaryons and between sugars (Table 3). The variation on xylose and on galactose was about three times that on sucrose. Similarly, the variation in the lag period on the new sugars was significantly greater than on the sucrose medium.

Table 4 compares the behaviour of asexual spores taken from single colonies grown on the three sugar media when placed on the same and different media. For each colony the highest survival rate of the spores is taken as 100, the shortest lag period as 0 hr.

Table 3. The Relative Proportions of Asexual Spores from Single Colonies of Two Lines on Sucrose Medium capable of Growth on Sucrose, Galactose and Xylose

(Highest survival-rate for each line taken as 100, lowest mean lag period as 0)

Line	Medium	Percentage of asexual spores giving a colony	Mean lag period
1_3	Sucrose	100·0	0 hr.
	Galactose	92·4	44 hr.
	Xylose	81·8	48 hr.
1_4	Sucrose	100·0	0 hr.
	Galactose	100·0	34 hr.
	Xylose	87·5	24 hr.

From Table 4 it can be seen that, for any one sugar, a greater percentage survival, smaller mean lag period, and less variation in lag period, is obtained on transfer to the medium to which the parent colony is adapted than to a different sugar.

Table 4

Medium to which mycelium adapted	Medium on which spores plated					
	Sucrose		Galactose		Xylose	
	Survival	Lag period	Survival	Lag period	Survival	Lag period
Sucrose	100	0 hr.	100	34 hr.	87·5	24 hr.
Galactose	52·9	0 hr.	100	0 hr.	23·5	47 hr.
Xylose	54·9	3 hr.	36·8	16 hr.	100	0 hr.

Jinks has shown that it is possible to select for cytoplasmic differences among the cytoplasmically heterogeneous colonies obtained from large numbers of single asexual spores[2]. Selection for any one character, for example, growth-rate, or perithecial density, was invariably accompanied by a correlated change in all the other characters investigated. It has now been found that selection for these characters is accompanied also by a change in the behaviour of the asexual spores from the selected colonies on the mercuric chloride medium. Cytoplasmic variants of various lines, selected for high growth rate, were found to give survival rates varying between 14 and 30 per cent on concentrations of mercuric chloride just below 3 μgm./ml. compared with a survival rate of 2–3 per cent for spores from unselected colonies. The change in survival rates of the spores brought about by selection in the complete absence of mercuric chloride is equal to, if not greater than, that brought about by prior adaptation of the parent colony to the mercuric chloride medium.

It is evident from these observations that the asexual spores of a colony show heterogeneity, of cytoplasmic origin, in their ability to grow on the media tested. Furthermore, there is a difference in the behaviour of hyphal and asexual spore transfers to the adaptive medium, hyphal transfers in general being more successful. This is most marked in the case of the mercuric chloride adaptations, where, even after adaptation of the parent colony, only a small proportion of the spores are capable of growth on the mercuric chloride medium.

The observations made here are in keeping with those made earlier on cytoplasmic differences affecting growth rate, perithecial density and other characters, in which asexual spores of a single homocaryon colony showed marked cytoplasmic heterogeneity, and colonies derived from asexual spore transfers and hyphal transfers differed in mean cytoplasmic content.

I am indebted to Dr. J. L. Jinks and Mr. L. G. Wigan for guidance and criticism.

[1] Jinks, J. L., *Nature*, **174**, 409 (1954).
[2] Jinks, J. L., *C.R. Lab. Carlsberg, Ser. Physiol.*, **23**, 183 (1956).

AGE AND OXIDATIVE PHOSPHORYLATION IN RAT LIVER AND BRAIN

By EUGENE C. WEINBACH* and JOEL GARBUS†

U.S. Department of Health, Education and Welfare, Public Health Service, National Institutes of Health, Bethesda, Maryland

THE scanty literature concerned with the ageing process in relation to enzymatic activity does not contain any systematic study of oxidative phosphorylation. Such a study is of considerable importance, because oxidative phosphorylation is generally regarded as the primary metabolic process in aerobic cells for the generation of adenosine triphosphate[1]. Recent experiments in the Laboratory of Tropical Diseases demonstrated an uncoupling of oxidative phosphorylation in particulate preparations of albumen gland correlated with decreased fertility in aged snails[2]. These findings suggested similar research with mammalian tissues. Concurrent studies in the Section on Ageing had shown no decline in the respiration of fortified rat brain homogenates associated with age[3], and it became of interest to study oxidative phosphorylation in these preparations. The availability of a colony of inbred rats especially maintained to study ageing facilitated a joint investigation in the two laboratories.

Sprague–Dawley rats, grossly free from disease, were killed by decapitation; the brain and liver were removed simultaneously, and immediately chilled in cold 0·25 *M* sucrose.

Mitochondria were isolated from liver tissues in 0·25 *M* sucrose essentially by the procedure of Schneider[4]. The mitochondria were washed once; each ml. of the final suspension represented 0·5 gm. of original tissue. The supernatant fluid which remained after the mitochondrial sedimentation was centrifuged at 20,000 *g* for 30 min. at 0° to obtain a clear, soluble fraction for the glycolytic experiments. Oxidative phosphorylation was studied in the liver mitochondria with the use of β-hydroxybutyrate as substrate[5]. The oxidation of this substrate was determined by colorimetric estimation[6] of the acetoacetic acid formed.

It may be seen in Table 1 that the amounts of phosphate esterified and β-hydroxybutyrate oxidized (formation of acetoacetate) were significantly lower —30 per cent—in the mitochondrial preparations of old rats as compared to those obtained from the younger (control) animals. In a few experiments, the preparations from animals only a few days old had a lower activity, while those from animals 8–20 days old displayed a higher activity than the preparations from the control group. On the other hand, in all age-groups, the phosphorus/acetoacetic acid ratios remained essentially the same. Thus, in the case of liver tissue, there was observed no uncoupling of phosphorylation from oxidation but a definite decrease in the level of both activities associated with age. No sex differences were noted. Independent tests revealed that the adenosine triphosphatase activity of freshly prepared mitochondria from the old rats was low and responded to uncoupling agents (latency effect) in the same manner as mitochondria from the control rats. Since all the data in Table 1 were calculated on a nitrogen basis, the reduced level of oxidative phosphorylation found in the older rats cannot be ascribed to the addition of less mitochondrial nitrogen to the reaction flasks. In fact, there was little difference in the amount of nitrogen found (micro-Kjeldahl) in the mitochondrial preparations from the older animals (average value, 1·42 mgm. nitrogen/ml.) as compared with the control preparations (1·45 mgm. nitrogen/ml.).

In contrast to these findings were the observations of glycolytic phosphorylation. As seen in Table 1, there was no decline in the anaerobic uptake of phosphate, nor was the glycolytic activity reduced in liver preparations from the old rats. These findings are analogous to our experience with snail tissue where glycolytic phosphorylation also did not decline with age.

Oxidative phosphorylation was measured in brain homogenates with succinate as substrate[7]. 10 per cent homogenates were prepared in 0·25 *M* sucrose

Table 1. EFFECT OF AGE ON OXIDATIVE AND GLYCOLYTIC PHOSPHORYLATION IN CELL-FREE FRACTIONS OF RAT LIVER*

Oxidative phosphorylation (mitochondria)				
Age	No. of exps.	P uptake (μM/mgm. N)	Acetoacetate (AA) formed (μM/mgm. N)	P/AA
3 months (control)	14	16·8 ± 1·42	6·0 ± 0·68	2·8
24–37 months	10	11·8 ± 1·55	4·0 ± 0·70	2·9
All t ratios are significant, $p < 0·001$				
Glycolytic phosphorylation (supernatant fraction)				
Age	No. of exps.	P uptake (μM/mgm. N)	Lactate formed (μM/mgm. N)	
3 months (control)	6	4·2 ± 1·97	4·3 ± 1·16	
24–37 months	6	5·0 ± 1·39	5·2 ± 1·20	

* Figures are mean values ± one standard deviation

Oxidative phosphorylation. Each flask (main compartment) contained in a final volume of 2·0 ml. $4·0 \times 10^{-3}$ glycylglycine buffer, *p*H 7·4, $2·5 \times 10^{-3}$ *M* DL-β-hydroxybutyrate, 1×10^{-3} *M* potassium phosphate, *p*H 7·4, $2·5 \times 10^{-3}$ *M* adenosine diphosphate (Pabst), $1·2 \times 10^{-4}$ diphosphopyridine nucleotide (Pabst), $1·5 \times 10^{-4}$ *M* cytochrome *c*, $2·5 \times 10^{-3}$ *M* glucose, 0·4 mgm. hexokinase (Sigma), 5×10^{-3} *M* magnesium chloride, $1·5 \times 10^{-3}$ *M* sodium fluoride (added last) and 0·5 ml. of mitochondria (added at zero time). The flasks were transferred immediately to the Warburg bath at 30°. At the end of 20 min. 0·2 ml. of 25 per cent perchloric acid was tipped in from the side arms to stop the reaction. See ref. 5 for additional details.

Glycolytic phosphorylation. Each flask contained in the main compartment $1·25 \times 10^{-3}$ *M* potassium bicarbonate, $2·0 \times 10^{-3}$ *M* fructose diphosphate (Schwarz), 5×10^{-3} *M* magnesium chloride, 5×10^{-3} *M* potassium pyruvate, $1·25 \times 10^{-3}$ *M* adenosine diphosphate, $2·5 \times 10^{-3}$ *M* glucose, 0·4 mgm. hexokinase, $4·0 \times 10^{-3}$ *M* nicotinamide, $1·2 \times 10^{-2}$ *M* diphosphopyridine nucleotide, $1·0 \times 10^{-3}$ *M* fluoride (added immediately prior to enzyme) and 0·5 ml. of supernatant fluid obtained as described in the text. Each side arm contained 1×10^{-3} *M* potassium phosphate which was added at zero time. Final volume 2·0 ml. Gas phase: 5 per cent carbon dioxide and 95 per cent nitrogen. Incubated 20 min. at 30°.

* National Institute of Allergy and Infectious Diseases, Laboratory of Tropical Diseases.
† National Institute of Mental Health, Laboratory of Psychology, Section on Ageing.

Table 2. Effect of Age on Oxidative Phosphorylation in Brain Homogenates*

Age	No. of exps.	O_2 uptake (μatoms/mgm. dry wt.)	P uptake (μM/mgm. dry wt.)	P/O
3–8 months (control)	10	0·66 ± 0·06	1·08 ± 0·09	1·64
22–33·5 months	10	0·65 ± 0·10	1·05 ± 0·16	1·61

* Figures are mean values ± one standard deviation.

Each flask contained in a final volume of 3 ml. $1{\cdot}2 \pm 10^{-1}$ *M* potassium phosphate, *p*H 7·4, 1×10^{-1} *M* sodium succinate, $1{\cdot}2 \times 10^{-2}$ *M tris*† buffer, *p*H 7·4, 5×10^{-3} *M* magnesium chloride, 2×10^{-3} *M* adenosine triphosphate (Sigma), 5×10^{-4} *M* diphosphopyridine nucleotide, $1{\cdot}5 \times 10^{-4}$ *M* cytochrome *c*, 2×10^{-1} *M* glucose, 0·5 mgm. hexokinase, 2×10^{-3} *M* potassium fluoride and 1 ml. 10 per cent homogenate. 0·2 ml. 10 per cent potassium hydroxide in centre well. Incubated in air for 30 min. at 30°. For details see ref. 7.
† *Tris* (hydroxymethyl) aminomethane.

and aliquots immediately added to chilled Warburg vessels containing all other components. As seen in Table 2, and in contrast to the liver studies, no decline was found in the oxygen consumption or phosphate uptake in homogenates from the old rats as compared with the controls. However, the lack of decline in oxygen consumption is in accord with previous respiration studies[3]; and in addition, the phosphate findings suggested that the coupled phosphorylation also is not depressed with age in the brain tissue. These results, together with the liver studies, indicate that in neither organ is there a change in the phosphorus/oxygen ratio with age. On the other hand, the lower absolute level of substrate oxidation and of the coupled phosphorylation found with liver, but not with brain, may be a reflexion of differences in tissue susceptibility to senescence.

Although the activity of some enzymes may increase with age[8], a general concept of ageing is one of progressive decline in the metabolic activities of the cell. If the *in vitro* experiments reported here with liver tissue are a valid reflexion of hepatic metabolism *in vivo*, then the decline in the absolute level of oxidative phosphorylation strongly supports this concept. It is of interest that studies with rat liver homogenates[9] did not show any significant correlation between age and oxygen consumption. The possibility exists that in cell-free homogenates, amply supplied with substrate and co-factors, age differences in metabolic behaviour which may be operating *in vivo* are masked to some extent *in vitro*. Perhaps isolated mitochondria represent a more subtle tool, because of their unique morphology and fragility, for investigating the ageing process. The studies with liver suggest the possibility in some tissues of a shift in phosphate metabolism from oxidative to glycolytic exergonic reactions accompanying senescence. Work is in progress to explore this possibility as well as other facets of the relation of ageing to enzymatic activity.

1 Lehninger, A. L., The Harvey Lectures, 1953–1954, 176 (Academic Press, Inc., New York, 1955).
2 Weinbach, E. C., *Arch. Biochem. Biophys.* (in the press).
3 Garbus, J., *Amer. J. Physiol.*, **183**, 618 (1955).
4 Schneider, W. C., in Umbreit, W. W., Burris, R. H., and Stauffer, J. F., "Manometric Techniques and Tissue Metabolism", 148 (Burgess Publishing Co., Minneapolis, 1949).
5 Lehninger, A. L., and Smith, S. W., *J. Biol. Chem.*, **181**, 415 (1949).
6 Walker, P. G., *Biochem. J.*, **58**, 699 (1954).
7 Hunter, jun., F. E., "Methods in Enzymology" (edit. S. P. Colowick and N. O. Kaplan), 2, 610 (Academic Press, Inc., New York, 1955).
8 Ross, M. H., and Ely, J. O., *J. Frank. Inst.*, **258**, 63 (1954).
9 Reiner, J. M., *J. Gerontol.*, **2**, 315 (1947).

COSMIC-RAY INTENSITY AND GEOMAGNETISM

By Prof. WALTER ELSASSER
University of Utah

and Prof. E. P. NEY and Prof. J. R. WINCKLER
University of Minnesota

In a series of papers, E. and O. Thellier[1] have measured the remnant magnetism of ancient bricks. By comparison of the original magnetic moment of a sample with the moment acquired by heating above the Curie point and cooling in the present Earth's field under proper conditions, they have deduced the magnitude of the total Earth's field in ancient times when the bricks were fired. The results are summarized in Table 1.

Table 1

Source of sample	Date	*H* (gauss)
Carle Sainte-Beuve	1933	0·456
Palais Ribour–Lille	1465	0·56
Gallo-Roman remains	≈ A.D. 200	0·71

During the past two thousand years, the total field intensity in France appears to have dropped 65 per cent. We should like to point out that, if such a decrease has been general over the Earth's surface, the incident flux of cosmic rays and the rate of production of radio carbon must have increased during this period. The change in the carbon-14 inventory may be estimated as follows:

(1) Assume that the rate of production of carbon-14 is proportional to the *particle* flux of cosmic rays over the Earth's surface. This implies that the production per primary does not depend on energy, that is, at higher cosmic-ray energies the energy goes predominantly into mesons rather than an increasing flux of nucleons per primary. In Table 2 we compare the measured total primary flux at each latitude[1] with the neutrons absorbed in a column of the atmosphere 1 cm.² in cross-section at each latitude[2]. The neutron captures per primary particle (column 4) are reasonably constant up to the latitude of the 'knee' (≈ 58°).

Table 2

Geomagnetic latitude	Primary flux (No./cm.²-sec.-ster.)	Neutron captures/cm.²-sec.	Neutron captures/primary particle	$\left(\frac{Pc}{e}\right)$ min. (gauss-cm.)
0	0·021	0·48	3·6	$5{\cdot}0 \times 10^{9}$
20	0·025	0·64	4·0	$3{\cdot}86 \times 10^{9}$
28	0·033	0·88	4·3	$3{\cdot}02 \times 10^{9}$
41	0·053	1·35	4·1	$1{\cdot}62 \times 10^{9}$
51	0·095	1·80	3·0	$0{\cdot}78 \times 10^{9}$
58	0·15	2·05	2·2	$0{\cdot}39 \times 10^{9}$
90	0·15	2·15	2·3	0

(2) Assume that the primary integral number-rigidity spectrum has the form:

$$N_{\lambda}^{+}(>E) = C\Big/\left(\frac{Pc}{e}\right)^{n} \quad \infty > \frac{Pc}{e} > \left(\frac{Pc}{e}\right)_{0} \qquad (1)$$

C is a constant and n is the power law exponent. The integral spectrum is constant for $\left(\frac{Pc}{e}\right) < \left(\frac{Pc}{e}\right)_{0}$ corresponding to the knee observed in the latitude effect of primaries, and there has the value $C\Big/\left(\frac{Pc}{e}\right)_{0}$. From the data in columns 2 and 5 of Table 2, we find that $n = 0{\cdot}93$, $C = 4{\cdot}03 \times 10^{5}$ and $\left(\frac{Pc}{e}\right)_{0} = 0{\cdot}39 \times 10^{7}$ gauss-cm. at $\lambda = 58°$. To facilitate the further computations, we assume $n = 1$.

(3) Assume that the average minimum $\frac{Pc}{e}$ at any latitude is that corresponding to a vertically incident particle. The solid angle available to particles of $\frac{Pc}{e} > \left(\frac{Pc}{e}\right)_{\text{min. }(\lambda)}$ is $\Omega = 2\pi$.

The flux over the entire Earth's surface in particles per second, Φ, is then given by:

$$\Phi = \Omega \int_{0}^{\lambda'} C\Big/\left(\frac{Pc}{e}\right)_{\text{min. }(\lambda)} 2\pi a^{2} \cos\lambda d\lambda + \Omega \int_{\lambda'}^{\pi/2} C\Big/\left(\frac{Pc}{e}\right)_{0} 2\pi a^{2} \cos\lambda d\lambda \qquad (2)$$

where λ' is the geomagnetic latitude of the knee.

From geomagnetic theory we know that the critical value of the Störmer variable r_{0} for the vertical direction is $r_{c} = \frac{\cos^{2}\lambda}{2}$. Since by definition $r_{0}^{2} = a^{2}\Big/\frac{eM}{Pc}$, where a is radius of the Earth, M is magnetic moment of the Earth, if we set $r_{c} = r_{0}$ then,

$$\left(\frac{Pc}{e}\right)_{\text{min. }(\lambda)} = \frac{\cos^{4}\lambda}{4} \cdot \frac{M}{a^{2}} \qquad (3)$$

By substituting (3) in (2) we obtain:

$$\Phi = \frac{A}{M}\left\{\int_{0}^{\lambda'} \frac{d\lambda}{\cos^{2}\lambda} + \frac{1}{\cos^{4}\lambda'}\int_{\lambda'}^{\pi/2} \cos\lambda d\lambda\right\} \qquad (4)$$

$$A = 8\pi a^{4}\Omega C$$

$$n = 1$$

The integrals in the brackets are functions of M as the limits contain the cosmic ray 'knee', λ'. At the 'knee' $\cos^{4}\lambda' \cdot M$ = constant, from (3). Calculations show that the dependence of Φ on M given by (4) may be well represented by the relation $\Phi = \frac{C_{1}}{M^{0{\cdot}52}}$, and then the rate of production of carbon-14 by

$$P(t) = \frac{C_{2}}{[M(t)]^{0{\cdot}52}} \qquad (5)$$

remembering that the magnetic dipole moment is dependent on time. The differential equation for the carbon-14 inventory over the Earth is then:

$$\frac{dI}{dt} = P(t) - \lambda_{1} I \qquad (6)$$

where λ_{1} is the decay constant for[4] carbon-14 = $\frac{0{\cdot}693}{5568}$ years^{-1}.

To carry out the integration of (6) the function $P(t)$ must be known over all past time, whereas the experimental magnetic field data only extend back for two thousand years. Therefore, to estimate the *minimum* effect consistent with these data, we make the following assumption:

$$P(t) = P_{0} = \text{const.} \quad t < 0$$

$$P(t) = P_{0} \exp \lambda_{2} t \quad 0 < t < 1933 \text{ years A.D.}$$

The values in Table 1 are well fitted by the exponential if we make $\lambda_{2} \frac{1}{7950}$ years^{-1}. Also $P_{0} = C_{2}/M_{0}^{0{\cdot}52}$

The integration of (6) then yields:

$$I = \frac{C_{2}}{M_{0}^{0{\cdot}52}\lambda_{1}(\lambda_{1}+\lambda_{2})} \cdot (\lambda_{2}\exp(-\lambda_{1}t) + \lambda_{1}\exp(\lambda_{2}t)) \qquad (7)$$

We then find that the relative carbon-14 inventory at $t = 0$ and $t = 1933$ is

$$\frac{I\ (1933)}{I\ (0)} = 1{\cdot}018$$

From the radioactive decay equation as given, for example, by Libby (ref. 4, p. 9), we find that an object about 2,000 years old would be dated too old by 240 years. This is scarcely outside the errors in the dating process even for a good sample, and probably would escape detection (see, for example, ref. 4, Fig. 1).

It is clear, however, that if the magnetic field has been decaying for longer periods of time than the two thousand years covered by the Thellier data, much larger discrepancies in carbon-14 dating might arise. If the decay were exponential with the same constant $\lambda_{2} = \frac{1}{7950}$ years^{-1} for four thousand years, samples of this age should exhibit a specific carbon-14 activity too low by an amount corresponding to an age 1,000 years too old. This seems to be outside the errors indicated by Libby.

One important consideration is that the Thellier data apply locally in France and may not be representative of the overall dipole field. The secular analysis of Vestine[5], for example, extending over forty years, shows that local rates of change are large enough to produce such variations if they persist sufficiently long. This would require harmonic components in the secular variation with periods longer than a hundred years. However, in past geological history there is good evidence for very large changes in the magnitude of the dipole field and its orientation, including complete reversals[5,6]. Certainly one might anticipate that major changes have occurred in the Earth's magnetism in the period covered by the carbon-14 dates. The considerations brought forward here will have greater significance if knowledge of the ancient magnetism of the Earth could be extended to earlier times.

[1] Thellier, E. O., *C.R. Acad. Sci., Paris*, **212**, 281 (1941); **214**, 382 (1942); **222**, 905 (1946); **223**, 1476 (1951); **234**, 1464 (1952).

[2] Anderson, K. A., *Phys. Rev.* (to be published).

[3] Soberman, R. K., *Phys. Rev.*, **102**, 1399 (1956).

[4] Libby, W. F., "Radiocarbon Dating", 2nd ed. (Univ. Chicago Press, 1955).

[5] Vestine, E. H., "Description of the Earth's Main Magnetic Field and its Secular Change, 1905–1945" (Carnegie Inst. Washington, Pub. 578).

[6] Elsasser, W. M., *Amer. J. Phys.*, **23**, 590 (1955); **24**, 85 (1956).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Attenuation of Host Reaction to Ovarian Homografts

Grafts derived from ovarian tissue which has been treated with glycerol and frozen to, and stored at, − 79° C. are endocrinologically active but contain comparatively few oocytes[1]. The oocytes which survive freezing and thawing can mature and undergo ovulation even in subcutaneous grafts[2]; but it is not yet known whether they are capable of normal fertilization and development. An approach to this problem involves orthotopic grafting at the ovarian site of the ovariectomized or sterilized recipient and, ideally, the use of a graft from a genetically distinguishable donor so that the source of any offspring produced is not in doubt. With the animals at present available at this Institute the latter requirement implies interstrain ovarian homografting and has led us to consider possible methods of attenuating or suspending the immunological reaction evoked by such grafts.

Several different procedures have been found to modify host reaction to homografts of various kinds[3]. The most attractive one from the present point of view is based on the observation that the growth of certain homologous grafts is enhanced by the previous intraperitoneal injection of the host with suspension of killed tissue of the same genetic composition as the prospective graft. This effect of such pretreatment, discovered and extensively studied in relation to tumour tissue[4], was not found by Kaliss and Spain[5] to occur with normal tissues; but Billingham, Brent and Medawar[6] have recently reported slight prolongation of survival of skin homografts following the pretreatment of the host with lyophilized tissue from the donor strain.

Two strains of rats, albino and hooded, are available at this Institute. With both of these, intrastrain ovarian homografts take and persist readily, while interstrain homografts are frequently accepted but persist less readily[7]. In particular, ovarian tissue from 'hooded' donors grafted into albino hosts usually ceases to function within a month, and this combination was therefore chosen for work on pretreating the recipients.

Ovaries of the hooded strain were homogenized in Ringer solution, frozen and thawed, once or repeatedly, and the suspension injected intraperitoneally. In an early experiment a suspension equivalent to a total of five pairs of ovaries was given to each albino recipient on days 14, 13, 12 and 4 before grafts were made from hooded donors. After 28 days, the grafts were still functioning in 7–10 of the pretreated recipients as compared with 7–27 of untreated but otherwise similar recipients for which records were available at the time. Afterwards, pretreatment was by a single intraperitoneal injection equivalent to four pairs of ovaries, groups of ten pretreated recipients and ten untreated recipients being used for each test. The first variable examined was the time of treatment before grafting, intervals of 1, 3 and 7 days being chosen in the light of the work of Kaliss and Day[8] on tumour grafts. Suggestive results were obtained with the recipients treated 7 days before the grafts were made, and three replications of this experiment were therefore carried out. In each, more grafts took and many more persisted in pretreated than in untreated recipients. The final result was that the grafts became active in 20–39 of the untreated recipients and remained active for 28 days or more in 7–39, the corresponding figures for the pretreated recipients being 31–40 and 24–40. The difference at 28 days is highly significant ($p = 0{\cdot}001$) and leaves little doubt that the pretreatment had had a significant effect upon the survival of the graft. The effect may be prolonged as continued observation in the first two experiments showed that active grafts were present in 0–20 untreated and 9–20 treated recipients at three months after grafting. Further experiments suggest that freezing of the suspension is not necessary, except perhaps to prevent the formation of ancillary grafts on the peritoneum. Suspensions subjected to ultrasonic vibrations are equally or even more effective. Work with other tissues and on component parts of the suspension is in progress, with the view of applying the technique to the extension and development of orthotopic ovarian grafting and the study of oocyte survival in frozen and stored tissue.

My thanks are due to Dr. J. H. Humphrey for much helpful information and advice, to Miss M. V. Mussett for the statistical analysis of the results, and to Miss M. P. Moylan for technical assistance.

A. S. Parkes

Division of Experimental Biology,
National Institute for Medical Research,
Mill Hill,
London, N.W.7.
Sept. 21.

[1] Parkes, A. S., and Smith, A. U., *Proc. Roy. Soc.*, B, **140**, 455 (1953).
[2] Deanesly, R., *J. Endocrinol.*, **13**, 211 (1956).
[3] Medawar, P. B., Ciba Foundation Symposium: "Preservation and Transplantation of Normal Tissues", 1 (1954).
[4] Snell, R. D., *Cancer Res.*, **12**, 543 (1952).
[5] Kaliss, N., and Spain, D. M., *Cancer Res.*, **12**, 272 (1952).
[6] Billingham, R. E., Brent, L., and Medawar, P. B., *Transplantation Bull.*, **3**, 84 (1956).
[7] Parkes, A. S., *J. Endocrinol.*, **13**, 201 (1956).
[8] Kaliss, N., and Day, E. D., *Proc. Soc. Exp. Biol., N.Y.*, **88**, 115 (1954).

Corneal Homografts

It has now been established that homografts of cornea and cartilage behave quite differently from skin homografts and can survive for long periods. The clinical success of the corneal graft has been known since 1878 [1], and there is ample evidence from histological and autoradiographic studies of experimental corneal homografts to confirm that they remain viable long after homografts of tissues such as skin are destroyed by the host tissues[2–4].

We have now examined more than a hundred corneal homografts implanted subcutaneously into guinea pigs and have found preservation of the corneal epithelium after two months, while at the end of three months the ground-substance survives unvascularized.

Experiments have recently been completed to test for any host sensitization. In fifteen guinea pigs a corneal homograft was inserted into the left lateral body wall, and four weeks later a second corneal homograft from the same donor was placed in a corresponding position on the right side of each animal and the grafts left in position for a further two weeks. Twenty-four hours before removal of the grafts the host animal was given 5 mc. of sulphur-

35 sulphate. First and second set homografts were then removed, sectioned, stained and prepared for autoradiography.

There was preservation of the corneal epithelium of both first and second sets of grafts, and no apparent difference in the uptake of sulphur-35 sulphate by the ground-substance compared to autoradiographs of 'control' cornea from host animal, indicating a normally functioning tissue. Thus there is no evidence of the sensitization of the host to corneal tissue which would be expected if the first grafts had produced a host-immune reaction.

It is our opinion that in both cartilage and cornea the mucopolysaccharides of the intercellular material are the specific substances responsible for the acceptance of these grafts by the host animal. A full account of these results will be reported elsewhere.

PAUL BACSICH
GEORGE M. WYBURN

Anatomy Department,
University of Glasgow,
Glasgow, W.2.

[2] Sellerbeck, E., *Arch. Ophth.*, **24**, 189 (1878).
[3] Bacsich, P., and Wyburn, G. M., *Proc. Roy. Edin.*, B, **62**, 321 (1947).
[4] Bacsich, P., and Wyburn, G. M., *Brit. J. Ophthal.*, **36**, 438 (1952).
[5] Bacsich, P., and Wyburn, G. M., *Trans. Bull.*, 1 (1954).

Sialoadenectomy and the Metabolism of Calcium-45 in Bone and Soft Tissues of the Mouse

IT has been reported that there are substances extractable from salivary glands which, when administered to animals, lead to a reduction of the plasma calcium[1]. Further observations[2] indicated the extracted proteins to be capable of promoting the calcification of hard tissues. Sialoadenectomy has been reported to reduce markedly the total ash, calcium, magnesium and phosphorus of the bones of the rat[3]. Our observation[4] that sialoadenectomized rats and mice exhibited reduced rates of growth, plus the study of Mari[5], who observed an increased growth-rate in chick embryo femurs, suggested that we study the metabolism of calcium in intact and sialoadenectomized animals.

The animals used in these studies were adult males, 25 ± 3 gm. The sialoadenectomized animals were prepared and treated as described previously[4]. There were not less than 8 and not more than 12 mice in each experimental group. Calcium-45 chloride was administered intraperitoneally dissolved in isotonic saline. The radiation dose was maintained at 5 μc. per 25 gm. body-weight. The specific activity of the calcium-45 was 102 μc. per mgm. calcium. The calcium-45 content of the tissues was determined 2 hr. after administration of the isotope. Animals were killed by exsanguination, tissues removed, washed with cold saline, blotted dry and samples therefrom weighed and digested by wet oxidation[7]. The clear digests were diluted to convenient volumes and aliquots plated on to tared glass planchets and dried. Radioassay was performed with the aid of a gas-flow counter and counting was extended in time to give a 2 per cent statistical error. Conventional corrections for decay, dilution and self-absorption were applied as required.

The calcium-45 incorporation into bone and nearly all the soft tissues (thymus and lung excepted) was greater in the sialoadenectomized mice (Table 1). The bones (femurs) of the sialoadenectomized animals

Table 1. DISTRIBUTION OF CALCIUM-45 IN INTACT AND SIALOADENECTOMIZED MOUSE TISSUES 2 HR. AFTER INJECTION OF 5 μc. $^{45}CaCl_2$. (Results expressed as counts/min. per mgm. of tissue)

	Group	
	Intact	Sialoadenectomized
Femur	675 ± 35*	1,106 ± 111
Thyroid	229 ± 55	317 ± 53
Adrenal	80·1 ± 15·5	96·9 ± 14·1
Thymus	97·3 ± 18·2	67·0 ± 7·5
Skeletal muscle	48·3 ± 4·4	59·2 ± 6·1
Lung	52·8 ± 8·3	46·0 ± 5·3
Heart	33·0 ± 1·6	43·3 ± 3·2
Spleen	28·2 ± 3·3	38·2 ± 8·1
Kidney	31·6 ± 2·6	37·7 ± 3·5
Testes	20·3 ± 1·5	31·7 ± 2·9
Brain	16·8 ± 1·3	22·0 ± 9·0
Liver	9·8 ± 1·1	14·1 ± 1·5

* Standard error of the mean.

concentrated calcium-45 1·64 times more than did the intact controls, liver 1·44, kidney 1·20, brain 1·31, spleen 1·36, heart 1·30, lung 0·87, muscle 1·23, thymus 0·68, thyroid 1·39, adrenal 1·21, testes 1·56. The generally higher uptake of calcium by the sialoadenectomized mice suggested that the animals were depleted in calcium and that a calcium-balance study was desirable. A three-day balance was performed on intact and sialoadenectomized mice using a finely powdered commercial grain ration, the calcium content of which we found by analysis to be 1·02 per cent. The results of the balance study (Table 2) show a reduced intake by the sialoadenectomized mice, a higher fæcal output and a lower urinary output, indicative of decreased absorption of dietary calcium. The reduced urinary excretion was investigated with calcium-45 and found to be 38 per cent of control values in a 24-hr. test. The balance study on dietary calcium indicated a 52 per cent difference, but this discrepancy is obviously due to the different routes of administration and consequently the degree of absorption.

In a single experiment, the 2-hr. uptake of strontium-89 was measured in intact and sialoadenectomized animals. The activity of the sialoadenectomized animal femurs was 175 per cent of control values. This we feel to be indicative of a mineral depletion resulting from the sialoadenectomy. It is interesting to note that the difference in calcium-45 uptake and strontium-89 uptake between intact and sialoadenectomized animals is of the same order of magnitude.

The interpretation of the observed differences in the calcium metabolism of sialoadenectomized animals is at present difficult to explain. The results presented here suggest interference with the absorption of calcium from the digestive tract. Also, previous studies indicated that sialoadenectomy inhibits thyroid activity in a manner involving the hypophysis[8]. Since the thyroid has been shown to be related to calcium absorption, and further, since the growth hormone of the hypophysis regulates the function of new bone tissue and also influences the digestive secretions[9], these current observations indicate that the physiological function of the salivary glands needs re-evaluation.

Table 2. CALCIUM BALANCE ON SIALOADENECTOMIZED AND INTACT MICE, *ad lib.* FEEDING (Results expressed as mgm.kgm./24 hr.)

Group	(*A*) Calcium intake	(*B*) Fæcal calcium	(*C*) Urinary calcium	(*D*) Calcium balance (*A–B–C*)
Intact	261·3	147·9	7·8	+ 105·6
Sialoadenectomy	232·2	158·7	4·1	+ 69·4

We wish to acknowledge the technical assistance of Mrs. Nancy Fogel. This study was sponsored in part by grants-in-aid from the National Institutes of Health.

Arthur W. Wase
Yu Sheng Louise Feng
Division of Biological Chemistry,
Hahnemann Medical College,
Philadelphia, Pennsylvania.
Aug. 29.

[1] Ito, Y., *Endocrinol., Jap.*, **1**, 1 (1954).
[2] Ito, Y., and Okabe, S., *Endocrinol. Jap.*, **2**, 195 (1955).
[3] Sasoki, T., *Acta Paediatrica*, **57**, 584 (1953).
[4] Wase, A. W., and Feng, L., *Fed. Proc.*, **15**, 1241 (1956).
[5] Mori, T., *J. Med. Sci. Showa Med. Coll.*, **13**, 15 (1953) (quoted in ref. 1).
[6] Wase, A. W., and Feng, L., *Nature*, **177**, 624 (1956).
[7] Wase, A. W., Boyd, M. J., and Goss, D. M., *Arch. Biochem. and Biophys.*, **51**, 1 (1954).
[8] Wase, A. W., and Feng, Y. S. L., *Acta Endocrinol.* (in the press).
[9] Baker, B. L., and Abrams, G. O., Intern. Symp. Hypophyseal Growth Hormone, 114 (October 1954).

Some Metabolic Effects of Poliomyelitis Virus on Tissue Culture

A desirable experimental condition for the study of metabolic effects of viruses on living organisms is that all or nearly all the cells be infected and that they be infected approximately simultaneously so that any metabolic changes can reasonably be expected to take place at about the same time throughout the cell population. This condition can readily be achieved with bacteriophages and their hosts, and a great deal of valuable work has been done with this system[1,2]. It has been virtually impossible to approximate to the necessary conditions with animal viruses and their intact hosts. The closest approximation has been achieved in the work with eggs; but complications introduced by host influences must be considered. As a result, our knowledge of metabolic changes induced in animal cells by animal viruses is limited. With the present emergence of tissue-culture techniques as an almost standardized procedure and the availability of animal virus suspensions of high titre, it has become feasible to undertake quantitative metabolic studies with animal viruses, and to relate any observed effects with virus growth. The present preliminary report is a summary of work on the effect of Type III poliomyelitis virus (Saukett strain) on some aspects of the metabolism of monkey kidney tissue culture; specifically, the effects of the virus on glycolysis and on the uptake by the tissue of glycine-2-carbon-14.

Two-ounce or thirty-two-ounce bottles of trypsinized monkey kidney tissue culture with lactalbumin hydrolysate or 199 medium were used in all the experiments[3]. Type III poliomyelitis virus (Saukett strain) was the infecting agent. It had a titre of about $10^{8.0}$ 50 per cent tissue culture infectious doses per 0·5 ml. The design of the experiments was as follows: the growth medium was poured off a number of two-ounce or thirty-two-ounce bottles of tissue culture, the cells washed with new medium, and new medium was added to the bottles. To half the bottles enough virus, in tissue culture medium, was added so that approximately seventy 50 per cent tissue culture infectious doses were present for each cell in the bottle. The other half of the bottles served as controls. Instead of the virus suspension, they received an equal volume of growth medium previously exposed to metabolizing cells. At intervals, beginning at the time of addition of the virus and continuing for 22 hr., groups of control bottles and groups of infected bottles were removed for analysis. Thirty minutes before a given batch of bottles were scheduled to be removed for analysis, glycine-2-carbon-14 was added. When the bottles were removed (after 30 min. of contact with the glycine-2-carbon-14) the fluids were poured off and analysed for lactic acid by the method of Barker and Summerson[4]. The cells were washed repeatedly with saline, scraped off the bottles, and the weight of the cells, as well as their radioactivity, determined. The quantity of lactic acid found at the start of each interval was subtracted from the amount of lactic acid found at the end of that interval, so that, in Fig. 1, the effect of virus on the rate of formation of lactic acid is presented, rather than the cumulative amount found.

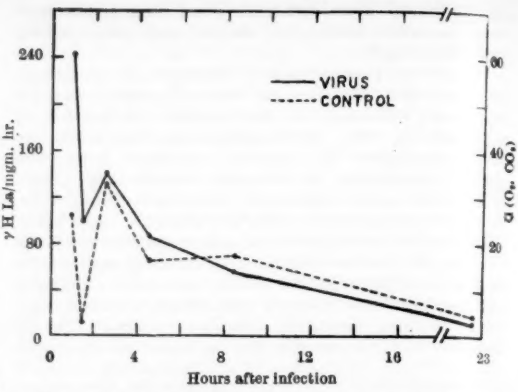


Fig. 1. Effect of poliomyelitis virus on aerobic glycolysis of monkey kidney tissue culture

It will be seen that within ½ hr. (in some experiments 1 hr.) there was a marked increase in the rate of lactic acid production in the infected cells as compared to the control cells. This increased rate continued during 6–12 hr., by which time the glycolytic rate in the infected cells had generally fallen to a level below that of the controls. In other experiments the virus was partially purified by a few cycles of differential centrifugation in order to reduce the likelihood that some constituent of the infecting medium other than virus was responsible for the observed effect. That the stimulation of glycolysis was actually due to the virus is strongly suggested by the fact that such partially purified virus caused an effect similar to that shown in Fig. 1.

Two other cytopathogenic substances, thimerosal and diphtheria toxin, at concentrations of 10 μgm./ml. and 1·5 Lf. units/ml., respectively, were tested for effect on glycolytic rate of monkey kidney tissue culture. It was found that while the thimerosal had no effect, the diphtheria toxin caused a greater increase in the glycolytic rate than did the virus, followed by a fairly rapid decline.

It might be noted that the glycolytic rate of normal monkey kidney tissue culture is extremely high. Such rates have generally been reported only for highly malignant tumour cells[5].

The effect of infection on the rate of uptake of the radioactivity of glycine-2-carbon-14 is shown in Fig. 2. The datum at each point represents the counts per minute of carbon-14 taken up in the preceding 30 min. by each milligram dry weight of tissue.

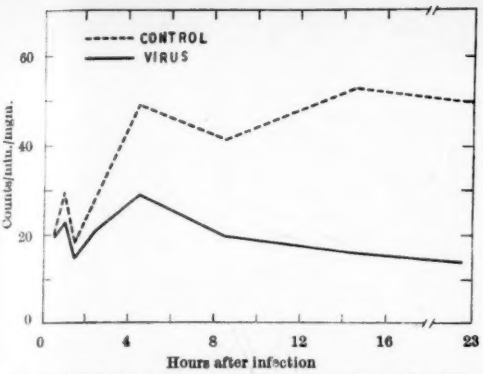


Fig. 2. Effect of poliomyelitis virus on uptake of glycine-2-carbon-14 by monkey kidney tissue culture

It will be seen that infection causes a significant and early depression of the rate of uptake of radioactivity. The partially purified virus described in the section on lactic acid produced the same effect. The other toxic agents tested (thimerosal and diphtheria toxin) both caused more rapid and marked depression of radioactivity uptake than did the virus, the uptake of the tissue after two hours of exposure to thimerosal being only 7 per cent of that of the controls.

In summary, exposure of monkey kidney tissue to high concentrations of Type III poliomyelitis virus leads, within an hour or less, to a stimulation of aerobic glycolysis and to a decrease in the rate of uptake of radioactivity from glycine-2-carbon-14. Two other cytopathogenic substances, thimerosal and diphtheria toxin, exert effects that have some qualitative similarities, as well as differences from those of the virus; but the markedly different quantitative aspects suggest the possibility of a difference in mechanism of action. A more detailed report will be published later.

HILTON B. LEVY
SAMUEL BARON
U.S. Dept. of Health, Education and Welfare,
Public Health Service,
National Institutes of Health,
National Institute of Allergy and Infectious Diseases and Division of Biologic Standards,
Bethesda, Maryland.
Sept. 6.

[1] Evans, jun., E. A., "Biochemical Studies of Bacterial Viruses" (Univ. Chicago Press, Chicago, 1952).
[2] Cohen, S. S., "Adv. Virus Res.", 3, 1 (1955).
[3] Melnick, L., *Ann. New York Acad. Sci.*, 61, 754 (1955).
[4] Barker, V. B., and Summerson, W. H., *J. Biol. Chem.*, 138, 535 (1941).
[5] Levy, H. B., Davidson, H. M., Reinhart, B. W., and Schade, A. L., *Cancer Res.*, 13, 716 (1953).

Action of the Hypophysis and of Dietary Protein on the Calcifying Tissues

It is well known that protein deficiency causes considerable interference with endochondral calcification in growing rats, the growth of the epiphyseal plate and the formation of calcified trabeculæ ceasing, the face of the plate being finally sealed off with bone[1,2]. Similar changes are seen after hypophysectomy[3]. In the case of the continually erupting incisor tooth of the rat, protein or amino-acid deficiency causes very slight changes, chiefly an interference with the calcification of the dentin[4-6]. Hypophysectomy induces very marked changes in the incisor, the chief defect being caused by the processes of eruption and incremental growth being differently affected. As a result, there is a relative overgrowth of dentin, the pulp cavity becomes smaller and later the formative end of the tooth is thrown into folds. Other degenerative changes also occur[7,8].

In recent experiments[9,10], young growing rats were put on diets containing 9·3 per cent protein, for from 10 to 117 days. Very marked abnormalities were seen in the epiphyses of the long bones, similar to those described above; they were completely prevented by raising the protein content of the diet to 18·8 per cent. The incisor teeth of the rats on the low-protein diet showed no significant changes in shape or rate of dentin formation or size of the pulp cavity, nor were the effects described by Hunter[4] and Bavetta *et al.*[5,6] seen, probably because the dietary conditions were less stringent than in their experiments.

The literature is not clear about the part the hypophysis plays in the changes which occur in bone during protein deficiency. Follis[1] says the question has not "been satisfactorily answered". Frandsen *et al.*[2] do not think the results in their experiments are due to reduced action of the gland. In view of the striking effects that occur in the teeth after hypophysectomy and the complete absence of such changes in protein deficiency, I conclude that the fundamental actions of the hypophysis and of protein on the hard tissues must be completely unconnected.

J. T. IRVING
Joint Dental Research Unit of the
Council for Scientific and Industrial Research
and the University of the Witwatersrand,
Johannesburg.
Sept. 6.

[1] Follis, R. H., "Metabolic Interrelations", 2nd Conf., Josiah Macy jun. Foundation, 221 (New York, 1950).
[2] Frandsen, A. M., Nelson, M. M., Sulan, E., Becks, H., and Evans, H. M., *Anat. Rec.*, 119, 247 (1954).
[3] Becks, H., Simpson, M. E., and Evans, H. M., *Anat. Rec.*, 92, 121 (1945).
[4] Hunter, H. A., *J. Dent. Res.*, 29, 73 (1950).
[5] Bavetta, L. A., Bernick, S., Geiger, E., and Bergren, W., *J. Dent. Res.*, 33, 309 (1954).
[6] Bavetta, L. A., and Bernick, S., *J. Amer. Dent. Assoc.*, 50, 427 (1955).
[7] Schour, I., and van Dyke, H. B., *Amer. J. Anat.*, 50, 397 (1932).
[8] Becks, H., Collins, D. A., Simpson, M. E., and Evans, H. M., *Arch. Path.*, 41, 457 (1946).
[9] Irving, J. T., and Budtz-Olsen, O. E., *Brit. J. Nutr.*, 9, 301 (1955).
[10] Irving, J. T. (unpublished results).

Synthesis of Phosphocreatine by Enzymes from Heart and Skeletal Muscle

THE transfer of phosphate from high-energy phosphate compounds of glycolytic origin (such as phosphoglycerylphosphate and enol-phosphopyruvate) to creatine has been considered possible only through the adenylic nucleotides[1]. Direct proof of this has been given so far only for enol-phosphopyruvate[2]. In the case of the acyl-phosphate, examination of thermodynamic data[3] shows that a direct transphosphorylation from phosphoglyceryl phosphate to creatine is possible and that an equilibrium constant of about 10 might be expected.

In order to test this possibility, a reconstituted system capable of phosphoglyceryl-phosphate genera-

Table 1. Final concentration of the components in a volume of 2 ml.: 0·025 *M* potassium phosphate buffer, *p*H 7·4; 0·0025 *M* magnesium chloride; 0·01 *M* potassium pyruvate; 0·0005 *M* diphosphopyridine nucleotide; 0·05 *M* creatine; aldolase 0·5 mgm. protein/ml.; triose-phosphate dehydrogenase 0·5 mgm. protein/ml.; lactic dehydrogenase, 0·25 mgm. protein/ml.; 0·0025 *M* fructose diphosphate ('direct' activity) or 0·01 *M* adenosine triphosphate (adenosine triphosphate–creatine phosphokinase).
Heart or skeletal muscle enzymes were assayed at levels between 0·3 and 4 mgm. protein/ml. Results are expressed in μmoles of phosphocreatine synthesized per mgm. of protein in 20 min. at 37°

	Type of enzyme preparation	Skeletal muscle		Heart muscle	
		'Direct' activity	Adenosine triphosphate–creatine phosphokinase activity	'Direct' activity	Adenosine triphosphate–creatine phosphokinase activity
A	Crude dialysed extract 1	0·02	0·002	0·006	0·08
A	Crude dialysed extract 2	0·09	0·07	0	0·02
A	Precipitation with ammonium sulphate up to 90 per cent of saturation	1·6	3·8	0	4·2
A	Precipitation with ammonium sulphate between 40 and 90 per cent saturation	0·84	1	0	1·4
B	Precipitation with ammonium sulphate between:				
B	(*a*) 0 and 25 per cent of saturation	0·09	0·01		
B	(*b*) 25 and 50 per cent of saturation	1·7	1·9		
B	(*c*) 50 and 75 per cent of saturation	3·1	1·3		
B	(*d*) 75 and 85 per cent of saturation	1	10·4		
B	(*a*) 0 and 45 per cent of saturation	0·3	0		
B	(*b*) 45 and 65 per cent of saturation	2·4	1·2		
B	(*c*) 65 and 85 per cent of saturation	1	11·5		

tion was assayed for phosphocreatine synthesis in the presence of enzyme preparations obtained, on one hand, from skeletal muscle, where glycolysis is an important source of high-energy phosphate compounds, and on the other, from heart muscle, which is known to depend mainly on aerobic phosphorylation mediated by the adenylic nucleotides. Preparations of the transphosphorylating enzymes were obtained from extracts of rat heart or skeletal muscle by repeated fractionation with ammonium sulphate; nucleotides were removed by treatment with charcoal and 'Dowex 1'.

In experiments designed to detect in these preparations the existence of a system capable of directly transferring phosphate from phosphoglyceryl phosphate to creatine, the acyl phosphate was generated in the same tube from fructose diphosphate by means of aldolase, triose phosphate dehydrogenase and lactic dehydrogenase in the presence of diphosphopyridine nucleotide, orthophosphate, magnesium and pyruvate. These three enzymes were also treated with charcoal. Commercial fructose diphosphate was purified by barium precipitation and charcoal treatment. Diphosphopyridine nucleotide was purified by anion-exchange chromatography. Hexokinase from the Sigma Chemical Co. was further purified with alumina gel and charcoal. Spectrophotometric analysis of the mixture for adenine nucleotides gave negative results.

The appearance of phosphocreatine after incubation for 20 min. at 37° C. was measured. The initial values were always zero.

Table 1 shows that the synthesis of phosphocreatine with fructose diphosphate as substrate occurs in the presence of enzyme preparations from skeletal muscle without adding any adenylic nucleotides. (This reaction will be referred to as 'direct' reaction.) Preparations from heart muscle, on the contrary, are devoid of such activity, although they are quite able to synthesize phosphocreatine if offered adenosine triphosphate. The possible existence of two separate enzymes for these two activities in skeletal muscle is suggested by the different patterns of fractionation (Table 1*B*).

Absence of catalytic amounts of adenosine diphosphate from the system was shown by using glucose in presence of hexokinase as phosphate acceptor instead of creatine. No inorganic phosphate is esterified in the absence of added adenosine diphosphate; a concentration of 10^{-5} *M* nucleotide allows an esterification of 1·5 μmoles in 20 min.

Synthesis of phosphocreatine from fructose diphosphate is enhanced from 3·9 to 4·8 μmoles in 20 min. by the presence of 2×10^{-5} *M* adenosine diphosphate, whereas 10^{-6} *M* nucleotide is ineffective. Since the skeletal muscle preparations contain the enzymes responsible for the transformation of 3-phosphoglycerate to enol-phosphopyruvate, this stimulation may be due to transfer of phosphate from the latter compound through adenosine diphosphate to creatine. Proof of this is the fact that 3-phosphoglycerate may be utilized for the synthesis of phosphocreatine only if 10^{-4} *M* adenosine diphosphate is present. This absolute requirement for the nucleotide may also be taken as a proof of its absence from our system.

The absence of adenine nucleotides is also confirmed by the fact that hexokinase does not inhibit the 'direct' synthesis of phosphocreatine. If this process is stimulated by 10^{-4} *M* adenosine diphosphate, a strong inhibition can be achieved by hexokinase. This would again point to a pathway where there is no competition for adenylic nucleotides.

Table 2 may also be interpreted in a similar way. Adenosine triphosphatase does not interfere with the 'direct' pathway of phosphocreatine synthesis, whereas it completely masks the adenosine triphosphate–creatine phosphokinase, the activity of which appears only after removing the adenosine triphosphatase.

Table 2. Results, conditions and concentrations for phosphocreatine synthesis as in Table 1. Adenosine triphosphatase assayed under the same conditions, but omitting creatine and using 0·05 *M* adenosine triphosphate. Activity is expressed in μmoles of 7-min. phosphorus hydrolysed per mgm. of protein in 20 min. at 37°

Type of enzyme preparation	'Direct' activity	Adenosine triphosphate–creatine phosphokinase activity	Adenosine triphosphatase
Fraction from skeletal muscle precipitated with ammonium sulphate at 40 per cent saturation	0·91	0·02	4·5
Same fraction after treatment with 0·25 volume of calcium phosphate gel of 1·8 per cent dry weight (ref. 5)	1·8	0·04	4·3
Same fraction after treatment with 0·5 volume of calcium phosphate gel	6·4	2	0

Preparation of phosphoglyceryl phosphate[6] enabled us to obtain a more direct proof of phosphate transfer from the acyl phosphate to creatine. This reaction occurs in the presence of enzyme from skeletal muscle, requires magnesium and is not inhibited by hexokinase. Since the acyl phosphate had also been treated with charcoal, these results strongly suggest the existence of a mechanism not linked to the adenylic nucleotides.

This investigation was partially supported by a grant from the Rockefeller Foundation. We are indebted to Dr. George Hodgson for helpful discussion.

Osvaldo Cori
Francisco Abarca
René Frenkel
Aida Traverso-Cori

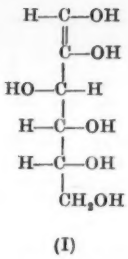
Institute of Physiology,
School of Medicine,
and
Department of Biological Chemistry,
School of Chemistry and Pharmacy,
Casilla 6524.
University of Chile,
Santiago.

[1] Needham, D. M., and Pillai, R. K., *Biochem. J.*, **31**, 1837 (1937). Meyerhof, O., Schulz, W., and Schuster, P., *Biochem. Z.*, **293**, 309 (1937).
[2] Needham, D. M., and van Heyningen, W. E., *Biochem. J.*, **29**, 2040 (1935).
[3] Ogston, A. J., and Smithies, O., *Physiol. Rev.*, **28**, 283 (1948).
[4] Fiske, C. H., and SubbaRow, Y., *J. Biol. Chem.*, **81**, 629 (1929). Stone, W. E., *J. Biol. Chem.*, **149**, 29 (1943).
[5] Kellin, D., and Hartree, E. F., *Proc. Roy. Soc.*, B, **124**, 397 (1938).
[6] Negelein, E., and Brömel, H., *Biochem. Z.*, **303**, 132 (1939).

Occurrence of 1 : 2 Dienol Glucose in Normal Blood : its Reaction with Alloxan and Chromatographic Identification

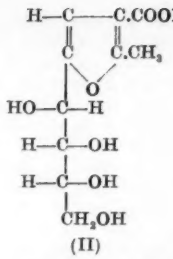
In 1922 when Winter and Smith[1] published results indicating for the first time that glucose in the blood of normal animals and men occurs in a form which is different from the ordinary α- and β-glucose. Lungsgaard and Holboll[2], from their polarimetric studies of blood, also concluded that a new form of glucose always occurs in the blood of normal human beings, but they could not say anything about its chemical nature or physiological significance.

It has been reported by West and Rinehart[3] that one molecule of an endiol compound reacts with two molecules of ninhydrin to give rise to hydrindantin ($C_{18}H_{10}O_6$), and it has recently been shown by us[4] that 1 : 2 dienol glucose (I), which is formed on hydrolysing the condensation product of glucose and acetoacetate (2-tetrahydroxy butyl 5-methyl 4-carbethoxy furan) (II), reacts with alloxan, which shows



(I)

1 : 2 Dienol glucose



(II)

Condensation product of glucose and acetoacetate

a structural resemblance with ninhydrin, at *p*H 7·2, and gives rise to the non-diabetogenic alloxanic acid.

It was thought that normal blood might also contain some such active principle, which might be able to combine with a small amount of alloxan in order to transform it to a non-diabetogenic product before it could reach the pancreas to bring about damage to the β-cells, and that diabetes might occur only when this reactive substance was completely depleted. This prompted us to examine normal blood to see if it also contains glucose in the endiol form which can react with alloxan, and to find out whether diabetic animals show the absence of such glucose in their blood.

For this, 2 c.c. of blood each from normal rabbits, deproteinized with 10 per cent trichloroacetic acid and brought to *p*H 7·2, was allowed to react with alloxan (4 mol. proportion per 1 mol. sugar) at 30° C. and the reducing sugar was estimated periodically by Hagedorn and Jensen's method[5] (Table 1).

Blood samples from a number of rabbits (six) injected with a diabetogenic dose of alloxan (collected 15 min. after the injection) were treated as above with alloxan; none gave any indication of reaction, thus showing that glucose occurring in more reactive form might have already combined with alloxan in the animal system.

Although the other reducing substances such as ascorbic acid and reduced glutathione are known to combine with alloxan, none of these has been found to interfere with the estimation of sugar by Hagedorn and Jensen's method. Hence the diminution of the reducing sugar as shown in Table 1 is due to its combination with alloxan.

It should be pointed out here that although the blood samples collected from different normal persons and from normal rabbits showed the presence of reactive glucose, ordinary glucose *D* never showed any change in its value when treated with alloxan under identical conditions. Nath *et al.*[6] have also observed that the hydrolysed condensation product combines with ninhydrin to give rise to a coloured compound, hydrindantin, thus giving additional

Table 1. Percentage of Blood Sugar reacted with Alloxan (*in vitro*)

(*A*) Normal rabbits

Animal No.	I	II	III	IV	V	VI	VII	VIII	IX	X	Average value and mean deviation
Per cent glucose reacted in ½ hr.	6·2	5·0	9·0	3·7	9·6	2·1	4·8	3·0	8·3	4·3	5·6 ± 2·6
Per cent glucose reacted in ½ hr.	6·2	5·0	11·1	11·0	17·0	6·4	8·5	5·1	14·8	5·6	9·1 ± 4·4

(*B*) Normal human subjects

Case No.	I	II	III	IV	V	IV	VII	VIII	Average value and mean deviation
Per cent glucose reacted in ½ hr.	8·0	2·3	13·0	8·5	13·3	3·2	6·2	2·0	6·4 ± 4·3
Per cent glucose reacted in ½ hr.	10·2	4·0	26·7	8·5	13·3	5·0	8·0	6·2	10·2 ± 6·8

No further change in glucose was observed after ½ hr.

evidence for the formation of 1 : 2 dienol glucose from the condensation product. Further, glucose in aqueous solution, during incubation at *p*H 7·2 for 24 hr., has been known to be partially transformed to 1 : 2 dienol glucose[7], and this incubated glucose has also been found to react with alloxan.

The results in Table 1 also account for the conversion of alloxan to alloxanic acid in the blood, when injected into normal animals, as observed by Seligson and Seligson[8]. It was shown by Meyer[9] that all endiols take up bromine instantaneously with intermediate formation of dibromoenol, which forms labile bromoketones. These bromoketones can oxidize hydrogen iodide and liberate iodine. This test was found to be positive with all the three substances, namely, glucose incubated at *p*H 7·2, hydrolysed condensation product (after removal of the ethereal extract) and deproteinized blood (after removal of the ethereal extract), thus showing definitely that blood contains dienol compounds. Since one important dienol compound, ascorbic acid, is also known to be present in blood, attempts were made to see if any confirmatory evidence for the occurrence of any other dienol compound in the blood could be made available, and if so in what form.

The technique of circular paper chromatography as used by Giri and Rao[10] was followed. Chromatograms with glucose, ascorbic acid and hydrolysed condensation product as well as with blood deproteinized by trichloracetic acid were obtained in duplicate on Whatman filter paper No. 1 of 18·5 cm. diameter, fitted with a wick at the central hole in Petri dishes placed in a closed chamber with solvent mixture containing butanol/acetic acid/water (40 : 10 : 50), the top layer being used. A special reagent, specific for endiol compounds, was found for the development of the chromatograms. It has been shown by Feigl and Cardoso[11] that certain reducing agents, which are without effect in acid solutions towards molybdate ions or which are only slightly active, reduce the latter immediately when phosphate ions, which produce complex phosphomolybdate ions, are present. Although glucose cannot reduce this compound in the acid medium to molybdenum oxide or 'molybdenum blue', ascorbic acid, which is a dienol compound, can do so. Ammonium phosphomolybdate reagent has been found by us to be reduced by 1 : 2 dienol glucose and was therefore selected for developing the chromatogram. The procedure is as follows: the paper chromatogram is immersed in 20 per cent alcoholic phosphomolybdic acid, allowed to drain and dried in a current of cold air; it is then washed in a 20 per cent ammonium nitrate solution acidified with a few drops of nitric acid, washed with water and dried by hot air.

Triphenyl tetrazolium chloride, which is commonly used for developing chromatograms with reducing sugars and sugar derivatives, was also used to develop another set of chromatograms with all the reducing compounds used previously as well as deproteinized blood.

While comparing the bands on the chromatogram with ascorbic acid, hydrolysed condensation product and deproteinized blood developed by the special phosphomolybdate reagent, ascorbic acid shows a band with R_F 0·52 and the blood shows the presence of a new dienol compound having its R_F value as high as 0·92 and similar to that with 1 : 2 dienol glucose. Ordinary glucose does not show any band with this reagent. Human diabetic blood also does not show any development of colour with the phosphomolybdate reagent, thus showing the absence of any endiol glucose.

The chromatogram developed with triphenyl tetrazolium chloride has a band with R_F 0·92 corresponding to 1 : 2 dienol glucose, which is liberated from the condensation product of glucose and acetoacetate on acid hydrolysis. Ordinary glucose has a much lower R_F value, which is in the neighbourhood of 0·32, and that for ascorbic acid is 0·52. The multiple-spot chromatogram with deproteinized blood shows clearly that a large portion of the reducing sugar resolves itself in the same region as that shown by 1 : 2 dienol glucose. The circular bands for ordinary glucose and ascorbic acid were also developed.

It is thus evident that a portion of the glucose in the normal blood occurs in the reactive endiol form which can easily react with alloxan and has the R_F 0·92 (against 0·52 for ascorbic acid) on a circular paper chromatogram when developed with a special reagent for endiol compounds only.

M. C. Nath
E. P. M. Bhattathiry
Department of Biochemistry,
University of Nagpur.

[1] Winter, L. B., and Smith, W., *J. Physiol.*, **57**, 395 (1922).
[2] Lungsgaard, C., and Holboll, S. A., *J. Biol. Chem.*, **65**, 320 (1925).
[3] West, E. S., and Rinehart, R. E., *J. Biol. Chem.*, **146**, 105 (1947).
[4] Nath, M. C., and Bhattathiry, E. P. M., *Metabolism*, **5**, 11 (1956).
[5] Hagedorn, H. C., and Jensen, B. N., *Biochem. Z.*, **135**, 46 (1923).
[6] Nath, M. C., Sahu, V. K., and Behki, R. M. (in preparation).
[7] Nef, J. U., *Ann.*, **357**, 214 (1907).
[8] Seligson, D., and Seligson, H., *J. Biol. Chem.*, **190**, 647 (1951).
[9] Meyer, K. H., *Ber.*, **47**, 835 (1918).
[10] Giri, K. V., and Rao, N. A. N., *J. Ind. Inst. Sci.*, **34**, 95 (1952).
[11] Fiegl, F., and Cardoso, H. T., *Rev. Brazil Biol.*, **2**, 117 (1942).

Release of Adrenaline and of Noradrenaline from the Adrenal Gland of the Cat and the Subsequent Resynthesis of these Amines

Several workers[1] have shown that there are various ways of causing a release of sympathomimetic amines from the adrenal medulla, for example, splanchnic nerve stimulation, insulin and nicotine. Few, however, have studied the subsequent resynthesis of these amines. It was thought possible that such an investigation might help to reveal the route by which adrenaline is synthesized biologically. Thus a study of the cat adrenal glands depleted by acetylcholine, the natural mediator of the splanchnic nerve[2], has been made.

The adrenal glands of atropinized, adult cats were depleted of their amine content by repeated, intravenous doses of acetylcholine. In all experiments one gland of each animal was used as a control and the depleted gland was compared with it. Also, control experiments were performed. The adrenaline and noradrenaline content of the glands was determined biologically, using the cat blood pressure and the cat nictitating membrane as separate test preparations. The results were calculated by a formula devised by Bülbring[3]. A qualitative chromatographic analysis also was made, in order to determine whether any other catechol amines were present.

Using acetylcholine, it was found that there was a similar percentage loss of adrenaline and of noradrenaline and that this was irrespective of the degree of depletion. The range of depletion was 7·1–86·5 per

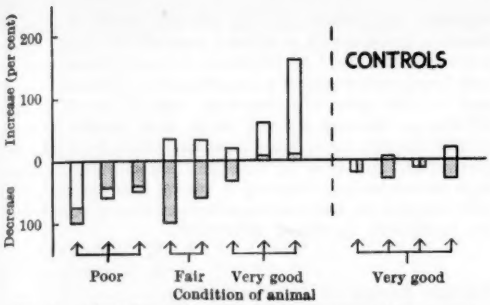


Fig. 1. Adrenaline and noradrenaline content of the second adrenal gland of the cat 2–3 days post-operatively. Adrenaline is shown by the stippled and noradrenaline by the white columns

cent. Correlating the amines lost from the depleted gland with the amines in the plasma obtained from the adrenal venous effluent, it was found that the percentages of noradrenaline in both the control gland and the depleted gland and in the plasma were the same. The total amount of amine in the plasma was equal to, or a little less than, the amines lost from the depleted gland. Hence there was no re-synthesis of the amines while the gland was being stimulated by the acetylcholine.

In an attempt to determine how long it would take for the depleted gland to replace the amine that it had lost, the animal was left on a warm operating table for as long as 17 hr. after the depletion of the glands. However, there was no increase in the amine content during that time, and if there was a gradual decline in the blood pressure, instead of the amine being replaced more was lost. This loss was prevented by the denervation of the gland; but, in spite of this, little or no resynthesis could be obtained. Thus in a further series of experiments, the animal was allowed to recover from the anæsthetic, following the depletion of both glands and the removal of one. After a period of several days the second gland was removed. It was found that 2–3 days post-operatively there was a small increase in the amine content, providing that the animal was in good condition

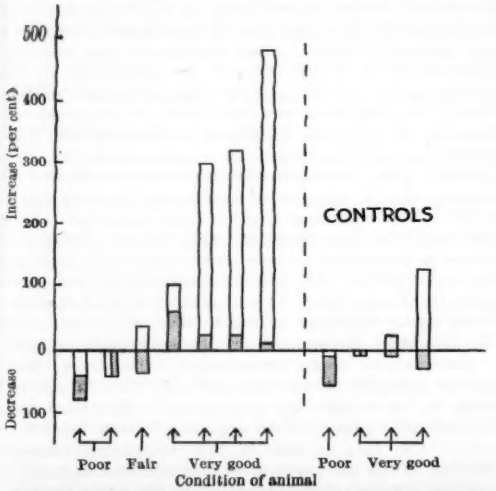


Fig. 2. Adrenaline and noradrenaline content of the second adrenal gland of the cat 6–7 days post-operatively. Adrenaline is shown by the stippled and noradrenaline by the white columns

(Fig. 1). After 6–7 days, unless the animal was in poor condition, when again there was a further loss of amine, there was a marked increase in the amine content. By this time, although the total amine had returned to its initial level, there was now an alteration in the proportion of adrenaline to noradrenaline present. Although the adrenaline content had increased by only a small amount, the noradrenaline content was many times its depleted level (Fig. 2). Thus it may be concluded that noradrenaline is synthesized at a much faster rate than adrenaline, under the conditions of these experiments, and it may be inferred that adrenaline is synthesized from noradrenaline.

Experiments are now in progress on the proportions of the two amines present in the gland after a re-synthesis period of one month. This work will be reported in detail elsewhere.

K. R. Butterworth*
Monica Mann

Department of Pharmacology,
School of Pharmacy,
University of London,
17 Bloomsbury Square,
London, W.C.1.
Aug. 24.

* Present address: Department of Pharmacology, St. Mary's Hospital Medical School, London, W.2.

[1] West, G. B., *Brit. J. Pharmacol.*, **5**, 165 (1950). Outschoorn, A. S., *ibid.*, **7**, 605 (1952). Erānkō, O., *Nature*, **175**, 88 (1955).
[2] Feldberg, W., Minz, B., and Tsudzimura, H., *J. Physiol.*, **81**, 286 (1934).
[3] Bülbring, E., *Brit. J. Pharmacol.*, **4**, 234 (1949).

Hereditary Defects of Temperate Bacteriophage

Several mutations of temperate bacteriophages are known which can be carried by the prophage of the lysogenic cell but bring about almost complete failure to release infectious particles when the cells are exposed to radiation[1–4]. One such group is known to be transmissible through all parts of the life-cycle including extracellular phage[2]; among these are the defects *i*1 and *i*2 of the bacteriophage *lambda* carried by *Escherichia coli K12*.

The phenotype of a double lysogen (a bacterium carrying two prophages) containing both a defective ($i = i1$ or $i2$) and a healthy (i^+) prophage is like that of a normal lysogen: the cell liberates healthy phage on induction. This suggests an analogy between the phage defects and the recessive lethals of higher organisms. If the analogy is valid, it would be expected that different loci would be involved in independently derived defective lysogens. We report here a single experiment upon recombination between *i*1 and *i*2 which demonstrates both the expected difference in the gene loci and a difference in the physiological consequences of the respective mutations to defective lysogeny.

To prove that the defects are not allelic, it is necessary to show that healthy phage can be derived by genetic recombination between *i*1 and *i*2. For this purpose, cultures of *lambda*-*i*1 or *lambda*-*i*2 lysogens were induced by small exposure to ultra-violet light. The cells almost all lysed 1½ hr. later, releasing a very small number, about 10^{-5} per cell, of i^+ phage and a rather larger number of i phage. Any remaining bacteria were killed by shaking the lysate with chloroform. The lysates were partially

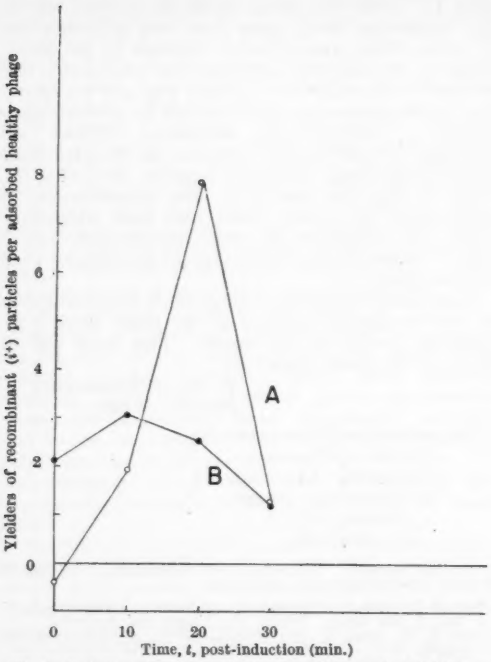


Fig. 1. Variation with time post-induction of the number of yielders of recombinant (i^+) particles per adsorbed healthy phage in infections of strain *C* 112 ($\lambda i2$) with $\lambda i1$ (curve *A*) and strain *C* 112 ($\lambda i1$) with $\lambda i2$ (curve *B*). The number of healthy phage yielders per adsorbed phage in homologous infections (*i*1 on *lambda*-*i*1 lysogens and *i*2 on *lambda*-*i*2 lysogens) was always less than 1·0 and this value is represented by the base line marked as 0

purified by differential centrifugation. A sample of phage from each lysate was now permitted to infect both a *lambda*-*i*1 and a *lambda*-*i*2 lysogen at various times, *t*, after these had been similarly induced. After allowing twenty minutes for phage adsorption, the induced infected cultures were assayed before lysis for yielders of infectious i^+ particles. After eliminating unadsorbed phage there are three sources of these particles in the induced infected cultures: (1) induced cells in which a reversion $i \rightarrow i^+$ has occurred; (2) cells which have been infected by an i^+ phage present in the infecting lysate as a result of a reversion $i \rightarrow i^+$ in the culture from which it was made; (3) in appropriate infections, cells in which a recombination between *i*1 and *i*2 has given rise to i^+ phage.

(1) and (2) were counted by separate assays of the uninfected induced culture and the infecting lysate. When *i*1 lysates infected induced *lambda*-*i*1 lysogens, or *i*2 lysates infected induced *lambda*-*i*2 lysogens, the total number of yielders of i^+ phage never significantly exceeded (1) + (2) at any time, *t*. Similarly, timed heterologous infections (*i*1 on *lambda*-*i*2 lysogens and *i*2 on *lambda*-*i*1 lysogens) were also carried out and the fraction by which i^+ yielders exceeded (1) + (2) was plotted as a function of *t* (Fig. 1).

From Fig. 1 we conclude that: (1) Genetic recombination between *i*1 and *i*2 occurs. Therefore, two different loci, *i*1 and *i*2, are involved. (2) The situations (*A*) in which an *i*1 lysate infects an *i*2 lysogen, and (*B*) in which an *i*2 lysate infects an *i*1 lysogen, give rise to entirely different curves of recombination as a function of time. Therefore, *i*1 and *i*2 are physiologically dissimilar. (3) In (*B*) the yield of recombinants drops steadily when *t* exceeds 10 min., after a small initial rise; in (*A*) there is a very considerable and unexpected rise in recombination between $t = 0$ and $t = 20$ min. We conclude that if an *i*1 phage infects an induced cell too early, it is unable to wait within the cell for a later increased chance of fruitful recombination, that is, that the intracellular vegetative (recombining) form of *i*1 phage is unstable. For this concept we have independent evidence which will be published in detail elsewhere.

R. K. Appleyard
J. F. Whitfield

Atomic Energy of Canada, Ltd.,
Chalk River,
Ontario.
Aug. 24.

[1] Appleyard, R. K., *Genetics*, **39**, 440 (1954).
[2] Appleyard, R. K., *J. Gen. Microbiol.*, **14**, 573 (1956).
[3] Jacob, F., "Les bactéries lysogènes et la notion de provirus" (Masson et Cie, Paris, 1954).
[4] Jacob, F., and Wollman, E., *Ann. Inst. Pasteur*, **90**, 282 (1956).

Sodium and Potassium Changes occurring in the Hæmolymph of Insects at the Time of Moulting and their Physiological Consequences

An insect is in an extremely vulnerable condition during a moult, so that its behaviour must be completely adapted for the time being to the special problems associated with the moulting process. Ordinary reflexes and locomotor activity must be suppressed. It may even be harmful for some of the muscles to contract at this time while the cuticle is soft, for if they do so they will effect permanent distortions in the drying exoskeleton. The means by which the muscular activity is modified or suppressed are not known.

When a nymphal locust approaches the moult it ceases feeding and becomes progressively less and less active. For a few hours before the moult and for a few hours again afterwards, it is almost motionless, except when it is seeking a suitable position in which to moult. Reflex movements of the limbs can still be evoked at this time but the mechanical responses are extremely feeble. The weak muscular contractions may be partly due to the softening of the exoskeleton, and to internal changes in the muscle fibres, but electrical records obtained from the leg muscles of nymphal locusts with intracellular electrodes suggest that a partial neuromuscular block is present. The block is analogous to that produced by raising the potassium concentration in the tissue fluid[1]. The resting potential of the muscle fibres is low and the fast-fibre responses consist largely of junction potentials. About 24 hr. after the moult has been completed the muscle contractions are much greater, though they do not achieve their full power until about the third or fourth day after the moult. At this stage neuromuscular transmission is normal.

An analysis of the hæmolymph of moulting fifth-instar nymphs of *Locusta* and *Schistocerca* showed that in each case the potassium concentration is considerably greater than normal. It was decided to study the time-course of the potassium changes leading to the increased level and also any changes in sodium concentration occurring at the same time.

The time of moulting was anticipated by weighing marked hoppers daily and following the progress of

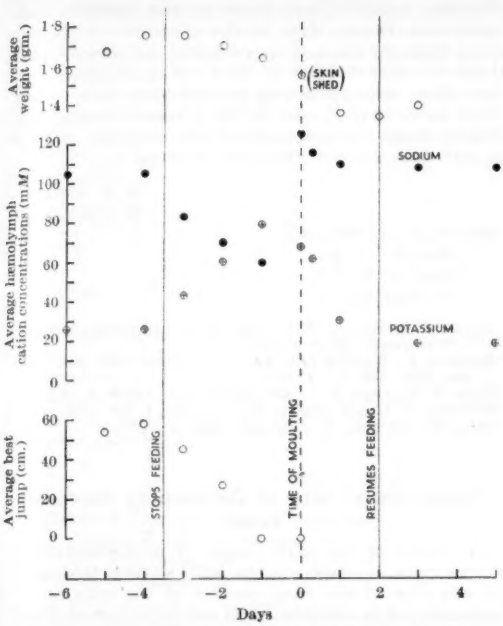


Fig. 1. Physiological changes occurring in fifth-instar nymphs of *Locusta* at the time of moulting. Top, changes in weight; centre, changes in hæmolymph sodium and potassium concentrations; bottom, changes in muscular power indicated by length of jump

each individual graphically. The weight of a hopper rises steadily, increasing by about 0·1 gm./day until eventually the animal ceases feeding. Thereafter the hoppers lose weight at the rate of about 0·6 gm./day, until after about three and a half days following the cessation of feeding the moult occurs. By following the changes in weight it is possible to ascertain approximately the time at which a hopper will moult.

It was found to be possible to follow the progress of a batch containing as many as 40 hoppers. A few individuals were removed from the batch at times estimated to be 4, 3, 2, and 1 days before their moult, during the moult and 6 hr., 1, 3 and 5 days following the moult. 2 c.mm. of hæmolymph was withdrawn from each hopper after making a small puncture behind the pronotum. The sodium and potassium contents were determined with the aid of a flame photometer. Blood was withdrawn from each hopper once only before the moult. Before being returned to the cage each animal was made to jump and the longest jumps were measured.

In Fig. 1 the results of the analyses of the hæmolymph of a group of gregarious-type fifth-instar hoppers of *Locusta migratoria migratorioides* R. and F. are plotted against time in relation to moulting. The average weights, average best jumps, times of cessation and resumption of feeding and the time of moulting are all indicated on the same time-scale. The time of moulting, which was known accurately in many cases or to within not more than 12 hr., was taken as a fixed point. Other points are subject to an error of the order of ±8 hr. in relation to the indicated time of onset of moulting.

The results show that starting at about the time when feeding stops, the potassium concentration in the hæmolymph rises steadily to a peak value of about 80 m.mol./l. while at the same time the sodium concentration falls to about 60 m.mol./l. During this time the sum of sodium plus potassium concentrations remains constant at about 140 m.mol./l. At the moment of moulting both the sodium and the potassium values are extremely variable, but it is evident that there is a fairly abrupt increase in the sodium level, values greater than 200 m.mol./l. having been obtained. There is a corresponding, although smaller, fall in potassium level at about the same time. Thereafter sodium and potassium soon attain the normal adult concentration.

The rise in potassium concentration is adequate to account for the depolarization and partial neuromuscular block which occurs and is probably responsible for much of the inactivity and weakness of the pre-moult hoppers. Potassium ions may therefore play an important part in the achievement of the behaviour changes associated with moulting. Preliminary investigations, now in progress, show that a rise in hæmolymph potassium concentration occurs before moulting in other insect orders.

G. Hoyle

Department of Zoology,
University of Glasgow.
Sept. 19.

[1] Hoyle, G., *J. Physiol.*, **137**, 90 (1955).

Change in the Metabolism of Micro-organisms grown on Irradiated Culture Medium

O. Wyss *et al.*[1] report that the growth of drug-resistant pathogen micro-organisms grown on culture media irradiated with ultra-violet rays increased strikingly without the micro-organisms themselves being exposed to the action of irradiation. The experiments demonstrated that mainly in cultures containing protein, under the action of ultra-violet rays the oxidation-reduction potential showed an average decrease of 300 mV., whereas under that of X-rays the decrease was 100–110 mV.; at the same time the value of the redox capacity increased too. In order also to find an energetic explanation for the change of the metabolism of the micro-organisms cultured on irradiated medium the following tests were carried out on aerobic cultures of *Serracia marcesens* strains. The strains examined were inoculated into the medium irradiated with ultra-violet rays of a quartz mercury lamp for 3 hr., and simultaneously the increase of the cell count, the oxidation-reduction potential and prodigiosin production were measured.

It was established that the growth of the cultures only started when the strain had completely exhausted the redox capacity, which had increased on the action of the irradiation of the medium with ultra-violet rays. Afterwards the growth of the cells and the oxidation-reduction potential of the cultures corresponded approximately to that of the controls; the prodigiosin production, however, decreased significantly.

A. Kráml
E. Pettkó
M. Sipos

Chemical and Biochemical Institute,
Medical University,
Szeged.
Aug. 29.

[1] Wyss, O., Haas, F., Clark, J. B. and Stone, W. S., *J. Cell Comp. Physiol.*, **35**, Supp. 2, 133 (1950).

Electrophoretic Evaluation of the Serum Proteins in Malignant Disease

It is well known that many diseases produce a marked alteration in the level of the total serum protein. Furthermore, it has been shown by electrophoretic analysis that certain diseases bring about distinctive changes in the relative concentrations of the different serum proteins. In early active tuberculosis[1] there is a rise in the γ-globulin fraction of the serum protein and a corresponding fall in the albumin-level. As the disease progresses the α^2-globulin concentration also increases and in advanced tuberculosis all the globulin concentrations are raised. In contrast, patients with nephrosis[2] show an increase in the α^2-globulin concentration which is usually associated with a decrease in the γ-globulin fraction.

In malignant disease there is an excessive protein demand by the rapidly growing tumour cells, which can only be met by utilizing the host's dispensable protein and the labile serum proteins. This drain on the body's store of protein is bound to be reflected as a change in the concentration of the different serum proteins. Mider *et al.*[3], using the Tiselius electrophoresis apparatus with a veronal buffer *p*H 8·5, found that the total plasma protein-level in malignant disease was below normal, the albumin-level was reduced but there was a significant rise in the level of the α-globulins; the β- and γ-globulin fractions also rose but the change in concentration was much less. Peterman and Hogness[4], using a similar method, found that in patients with carcinoma of the stomach the albumin-level was low, the α-globulins were raised, but the β- and γ-globulin-levels were normal. Gross and Snell[5] reported that there was no significant difference between the serum γ-globulin-levels of patients with malignant disease and those of healthy controls.

The present report concerns the results obtained from an electrophoretic evaluation of the serum protein-levels of twenty-four patients from the Dartford Group of Hospitals, Kent, suffering from malignant disease, which had been verified by histological examination. The patients were chosen at random, and their ages varied from thirty-one to seventy years. The majority of the tumours were situated in the genital or intestinal tracts and were at different stages of development, some being localized while others had metastasized widely. Blood samples were taken from each patient on admission and only the blood from those patients having normal temperatures, total and differential leucocyte counts, erythrocyte counts and hæmoglobin-levels were used. Blood samples were also taken from twenty-one healthy females of the same age-group to serve as controls.

The protein-level of each of the sera was estimated by first separating the different fractions by paper electrophoresis at *p*H 8·5 using a veronal buffer. The filter paper strips were then treated with bromphenol blue and the optical density of the protein dye complex was measured by means of a photoelectric cell. In this manner the percentages of the different proteins in relation to the total protein in the serum could be assessed.

The results showed that the sera of the patients with malignant disease had no distinctive electrophoretic pattern. The difference between the α^1-, α^2- and β-globulin-levels of the patients with malignant disease and those of the healthy controls was not statistically significant. The level of the serum albumin, however, was lower in the patients with malignant disease than in the controls. Although these findings are not in complete agreement with those of other workers it must be appreciated that only those patients having normal temperatures and blood pictures were used for the present investigation and the stage of development of the malignant tumour in each case was not taken into account.

R. S. Snell
W. Gross

Department of Anatomy,
King's College,
London, W.C.2.
Sept. 20.

[1] Seibert, F. B., Seibert, M. V., Atno, A. J., and Campbell, H. W., *J. Clin. Invest.*, **26**, 90 (1947).
[2] Raynaud, R., Robert-D'Eshouges, J., and Pasquet, P., *Bull. Acad. Nat. Méd.*, **138**, 111 (1954).
[3] Mider, G. B., Alling, B. L., and Morton, J. J., *Cancer*, **3**, 56 (1950).
[4] Peterman, M. L., and Hogness, K. R., *Cancer*, **1**, 100 (1948).
[5] Gross, W., and Snell, R. S., *Nature*, [178, 855 (1956)].

Intracellular Site of Developing Herpes Virus

A study of the early hours of multiplication of herpes virus in chick embryo cells[1] showed that some 90 per cent of the virus present in the cells at the beginning of incubation could not be detected 3 and 6 hr. later. The method of cell homogenization employed in this work to extract virus for titration left the cell nuclei intact, and the findings of Gray and Scott[2] suggested that the virus lost in the early hours of incubation might have made its way into the nuclei, and so escaped detection. This possibility was investigated.

Chorio-allantoic membranes of 10-day fertile hens' eggs were infected with herpes virus. After 2, 4, 6, 8 and 10 hr. incubation, membranes were excised, washed and put in diluted anti-herpes serum overnight at 4° C. The membranes were then washed, homogenized and diluted. Fixed and stained smears of diluted homogenate showed intact cell nuclei stripped of cytoplasm. The nuclei were deposited by centrifugation and the virus titre of the supernatant 'cytoplasmic fraction' measured. The nuclei were repeatedly washed, then half were suspended in dilute rabbit serum with 0·85 per cent sodium chloride and half in dilute rabbit serum with 6 per cent sodium chloride. These two suspensions were left overnight at 4° C. and then centrifuged, the supernatant containing 6 per cent sodium chloride being regarded as the 'nuclear fraction' and the other as a control. The virus titres of both were measured. Stained smears of the deposits showed that the 6 per cent sodium chloride solution had removed all basophilic material from the nuclei, leaving none intact except for a very few from erythrocytes; in the control, intact nuclei were numerous. The results of the virus assays, made by the pock-count method on chorio-allantoic membranes, are shown in Table 1.

It will be seen that at each interval the nuclear fraction contained more virus than the control, but less than one-tenth of that found in the cytoplasm. In three repetitions of this experiment the distribution of virus between the fractions has been the same as in this instance. If all the virus lost from infected cells soon after the onset of incubation[1] had entered nuclei these should contain up to nine times as much as the cytoplasm.

Table 1. Distribution of Virus in Chorio-allantoic Membrane Cell Fractions in the Hours Immediately after Infection

Fraction of chorio-allantoic membrane assayed	Number of lesions caused by 0·05 ml. of assayed material from membranes incubated for				
	2 hr.	4 hr.	6 hr.	8 hr.	10 hr.
Cytoplasmic fraction	60	120	50	80	1,000
Fifth wash of deposited nuclei	0	0	1	1	16
Control extract of nuclei	0*	0*	0*	1*	4*
6 per cent sodium chloride extract of nuclei (nuclear fraction)	3*	3*	1*	4*	90

* Average of eight eggs inoculated with undiluted material.

We may conclude, therefore, that the part of the initial uptake of herpes virus which is no longer demonstrable in the infected cells after 3 or 6 hr. of incubation has not entered the cell nuclei. Other hypotheses accounting for its disappearance are discussed elsewhere[1].

J. V. T. Gostling

The Bland-Sutton Institute of Pathology,
The Middlesex Hospital,
London, W.1.
Sept. 22.

[1] Gostling, J. V. T., and Bedson, S. P., *Brit. J. Exp. Path.* (in the press).
[2] Gray, A., and Scott, T. F. McN., *J. Exp. Med.*, **100**, 473 (1954).

Detection by Phenylalanine Tolerance Tests of Heterozygous Carriers of Phenylketonuria

Pauling introduced the term 'molecular disease' for the hereditary condition of sickle cell anæmia, in which the clinical signs in both the heterozygous carriers with the sickling trait, and the homozygous patients with the anæmia, are explained by the fraction of abnormal hæmoglobin molecules present[1]. Only a part of the total hæmoglobin is the abnormal type in the heterozygote with one abnormal gene, whereas nearly all the hæmoglobin is the abnormal type in the homozygote with two abnormal genes. An extension of this concept of molecular disease leads to the prediction that in hereditary diseases associated with the loss of activity of an enzyme, the asymptomatic heterozygotes should be identifiable by having less than the normal amount of the enzyme primarily involved in the disease[2].

The molecule the dysfunction of which is responsible for the hereditary disease of phenylketonuria is the liver enzyme concerned with the oxidation of phenylalanine[3]. Inactivity of this enzyme results in the high blood-levels of phenylalanine, the excretion of phenylpyruvic acid, and mental deficiency. Genetic studies have established this condition to be completely recessive, and no related mental or biochemical abnormalities have been found in the heterozygous parents or siblings of the patients[4]. The above considerations suggest, however, that the fraction of enzyme arising from the abnormal gene in the heterozygotes should be defective. This prediction is supported by the present findings from phenylalanine tolerance tests that known heterozygotes of phenylketonuria have lower capacities for metabolizing phenylalanine than do normal people.

Plasma-levels of L-phenylalanine were determined one, two and four hours after oral doses of 0·1 gm. of L-phenylalanine per kgm. body-weight, given after an overnight fast, in nineteen heterozygous individuals (parents of proved phenylketonuric patients) and an equal number of normal adult controls. L-Phenylalanine was measured by a modification of the bacterial decarboxylase method of Udenfriend and Cooper[5]. The fasting plasma phenylalanine-levels taken before the test in all individuals were within the range of 0·03 – 0·16 μmol./ml. The phenylalanine-levels in the heterozygotes during the test were on the average about twice those of the controls at each of the hourly intervals. The distinction between the groups was particularly clear at the fourth hour and by comparison of the sum of the three hourly levels used as an index approximating the area under the tolerance curve. The test was repeated on several individuals from each group with highly reproducible results. The means and standard deviations and the range of the values found are given in Table 1.

Table 1. Plasma L-Phenylalanine Levels after Ingestion of L-Phenylalanine

Values given are the means ± the standard deviation, and the ranges, in μmol. per ml. of plasma, found in 19 adult controls and 19 parents (heterozygotes) of known phenylketonuric patients

	Hours after dose			Sum of hourly levels
	1	2	4	
Controls	0·55 ± 0·186 (0·30–0·90)	0·55 ± 0·168 (0·29–1·02)	0·30 ± 0·076 (0·21–0·50)	1·41 ± 0·366 (0·87–2·19)
Heterozygotes	1·14 ± 0·187 (0·84–1·44)	1·03 ± 0·187 (0·72–1·44)	0·76 ± 0·202 (0·45–1·62)	2·93 ± 0·458 (2·10–4·02)

Comparison of the two groups on the basis of age, sex, weight, intelligence, or dose per square metre of body surface failed to reveal discrepancies which could account for the observed differences between the phenylalanine plasma-levels of the groups. The possibility was exceedingly small that such a difference could have occurred by chance ($P < 0·0001$). The excretion of phenylalanine during the nine hours following the oral dose was determined in about half the individuals. The amounts excreted were not different in the two groups and were insignificant in relation to the amounts disappearing from the blood during the test period. Phenylpyruvic acid in the urine during the same period was never found in the controls, and only in one heterozygote, who also showed the highest observed plasma-levels of phenylalanine. The most probable interpretation of these results is that the heterozygotes as a group have significantly less than the normal phenylalanine-oxidizing enzyme activity.

The test was also of value in distinguishing the phenotype of single individuals. The results in only a small fraction (about 15 per cent) of the individuals tested fell in the zone of overlap between the two groups. With more or less certainty, the remainder of the individuals could be clearly distinguished as belonging to one or the other group on the basis of the phenylalanine-tolerance test alone. The probability that an individual in one group might have levels at the mean for the other group was less than 1 in 20,000. This ability of the test to identify heterozygous individuals was examined in six normal siblings of proved phenylketonuric patients. Three gave results in the heterozygote range (four were expected on a statistical basis) and three were clearly normal. In addition, a typical heterozygote type of curve was obtained and confirmed in one individual

whose direct and collateral relatives over four generations did not include any cases of phenylketonuria or mental deficiency. Normal liver function was assumed for this individual on the basis of a negative history and physical examination and a bromsulphthalein test. Although phenylketonuria occurs rarely (1 in 25,000–40,000 people)[4], the heterozygous carriers are very much more common (half the square root of the frequency, or at least 1 in 100 people). In the absence of liver disease, heterozygosity for phenylketonuria is therefore the probable explanation for the high levels found in unsuspected individuals.

While the results in a single individual must be interpreted with caution, the abnormal values found in a group of known heterozygotes establish the decreased ability to metabolize phenylalanine as the phenotypic expression of a single phenylketonuria gene. This finding provides confirmation for the view that lack of the active phenylalanine-oxidizing enzyme is the primary lesion in phenylketonuria. Finally, the presence of part of the enzyme in an inactive form in the heterozygote with one abnormal gene, and nearly all the enzyme inactive in the homozygote with two abnormal genes, extends the concept of hereditary molecular diseases, based until now on the abnormal hæmoglobins, to those diseases called by Garrod[6] "inborn errors of metabolism".

This investigation was aided by a grant from the Playtex Park Research Institute; Grant *A* 567 from the National Institute for Arthritis and Metabolic Diseases, United States Public Health Service; and United States Atomic Energy Commission contract *AT*-(30-1)-901 with the New England Deaconess Hospital.

David Y.-Y. Hsia
Kathleen W. Driscoll

Department of Pediatrics,
Harvard Medical School; and
the Children's Medical Center,
Boston.

Walter Troll
W. Eugene Knox

Department of Biological Chemistry,
Harvard Medical School; and
the Cancer Research Institute,
New England Deaconess Hospital,
Boston.

[1] Pauling, L., "Harvey Lectures", **49**, 216 (1953–54).
[2] Knox, W. E., *Bull. Tufts-N.E. Med. Center*, **2**, 1 (1956).
[3] Jervis, G. A., *Proc. Soc. Exp. Biol. and Med.*, **82**, 514 (1953).
[4] Jervis, G. A., *Res. Pub. Assoc. Nerv. Ment. Dis.*, **33**, 259 (1954).
[5] Udenfriend, S., and Cooper, J. R., *J. Biol. Chem.*, **203**, 953 (1953).
[6] Garrod, A. E., "Inborn Errors of Metabolism", 2nd edit., H. Froud (Hodder and Stoughton, London, 1923).

Seeds of Pure Beta-ray Emitter (Yttrium-90) for Radiation Hypophysectomy

Pituitary ablation has recently been advocated for certain forms of advanced malignant disease with metastases, notably carcinoma of the breast. Such an ablation could be produced by irradiation, and gamma-ray emitters have been used interstitially by some workers[1,2]. For example, 10–20 mc. of radon in gold seeds has been implanted in the gland via the nostril and sphenoidal sinus[1], and seven out of twenty-five patients were reported to have benefited. In some cases, however, it was reported that defective vision ensued, possibly as a result of over-irradiation of the optic nerves or chiasma[1]. Small grains of unscreened radioactive gold metal have also been used[2] and in a series of fifty patients treated over eighteen months no damage to the optic nerves or chiasma was reported. However, with gamma-emitting materials, the danger is always present; it will be considerably less if a pure beta-ray emitter can be used. Colloidal beta-emitting solutions have been injected into the gland[3,4], while other workers[5] have used pellets of yttrium-90. This note is a preliminary account of the radiation properties of similar seeds now in use in this Hospital. They are cylinders of 3 mm. length and 1 mm. diameter and are inserted with a cannula via the nostril using an X-ray image intensifier as a visual aid.

Yttrium-90 is a pure beta-ray emitter with a maximum energy of 2·2 MeV. corresponding to a maximum range of 1 gm./cm.^{2} and having a radioactive half-life of 61 hr. It can be prepared as sintered rods of oxide which are cut to size. The seeds are irradiated in the atomic pile at the Atomic Energy Research Establishment, Harwell, at a high pile factor for a period of several days, the specific activity produced for a six-day irradiation at a pile factor of 12 being about 220 mc./gm. The average mass of the seeds is about 0·0074 gm., so that seeds of total activity of between 1 and 2 mc. are used; the effective activity available for external irradiation will, of course, be much smaller due to self-absorption in the seed.

Each batch of seeds is tested for uniformity by measuring the ionization current produced when the seed is held in the centre of a large ionization chamber. The radiation dose-rate and depth dose from a seed have been determined photographically. Determinations of beta-ray depth dose with film have been reviewed favourably[6]; it has been shown that they reproduced those made with an extrapolation chamber[7] and that they are independent of energy above about 1·5 MeV. maximum beta-ray energy[7,8]. The seed was held on the top of a stack of about 25 pieces of Kodak *K.S.*5 single-coated film which were compressed together in a jig of 'Perspex' and tissue-equivalent wax ('Mix D')[9] so as to give full back-scatter. From the densities observed on each film a depth–dose curve can be drawn; in order to obtain a measurable density on each film in a stack it was necessary to use several different exposure times varying from 20 to 120 sec. Each set of films was calibrated with exposures to a strontium-90 surface applicator of known beta-ray intensity; these also serve to standardize the photographic processing conditions.

The yttrium seeds have been found to give a dose-rate of 3,500 ± 200 rads/hr./mc. at a distance, in water, of 1 mm. from the centre of the cylindrical surface of the seed. Fig. 1 (curve *a*), which is the mean of eight separate determinations, shows the percentage depth dose in the film stack referred to the dose-rate at 1 mm. while (*b*) shows the corresponding derived curve in water which is regarded as equivalent to tissue. Curve (*b*) has been evaluated by measuring the intensity fall-off from the seed in air: from this, together with curve (*a*), the beta-ray absorption in film was calculated; the absorption was then corrected for the difference in density between film and water. The total dose delivered throughout the decay of the seed is 320,000 rads/mc. at a distance of 1 mm. in water.

Attempts have been made to deliver a minimum dose of 100,000 rads to the gland by distributing

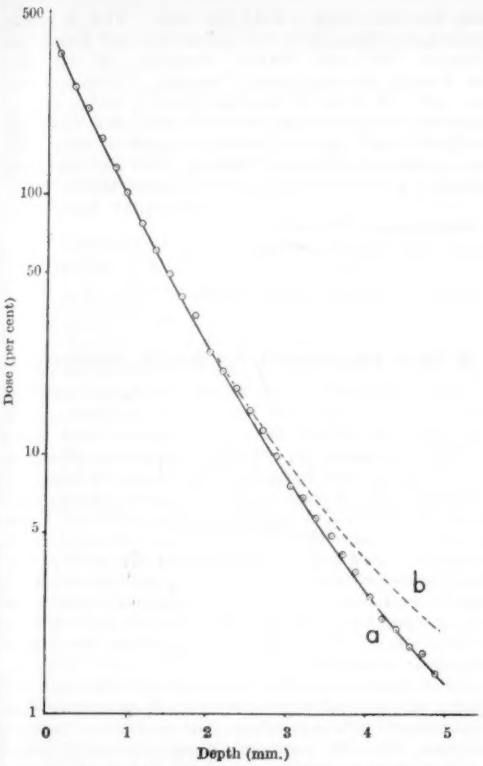


Fig. 1. Curves of dose against depth (100 per cent at 1 mm. depth): (*a*) in film; (*b*) in water

throughout its volume six seeds of average total activity about 9 mc. We are, for the moment, assuming a spherical distribution of dose around the seed.

So far, five patients have been treated, and in due course a more complete account of this technique will be published. We are indebted to Dr. Morrison of the Radiotherapeutic Research Unit and Dr. Russell Fraser of the Department of Medicine, who have carried out the treatments. We are also grateful to the Morgan Crucible Co., Ltd., London, S.W.11, for developing the sintering process.

J. R. Mallard
A. McKinnell

Department of Physics,
Hammersmith Hospital,

P. E. Francois

Medical Research Council
Radiotherapeutic Research Unit,
Hammersmith Hospital,
London, W.12.
Sept. 8.

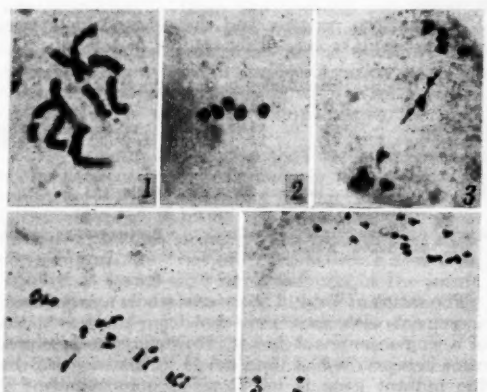
[1] Forrest, A. P. M., Brown, D. A., Morris, S. R., and Illingworth, C. F. W., *Lancet*, i, 399 (1956).
[2] Greening, W. P., *Lancet*, i, 728 (1956).
[3] Rothenberg, S. F., Jaffe, H. L., Putnam, T. J., and Simkin, B., *Arch. Neurol. Psychiat.*, Chicago, **73**, 193 (1955).
[4] Davies, F. L., *Lancet*, i, 670 (1956).
[5] Rasmussen, T. B., Harper, P. V., Yuhl, E., and Bergenstal, D. M., Argonne Cancer Research Hospital, Report No. 3 (obtainable from A.E.R.E., Harwell).
[6] Marinelli, L. D., *Radiol.*, **63**, 656 (1954).
[7] Tochilin, E., and Golden, R., *Nucleonics*, **11**, 26 (1953).
[8] Dudley, R. A., *Nucleonics*, **12**, 24 (1954).
[9] Jones, D. E. A., and Raine, H. C., *Brit. J. Rad.*, **22**, 549 (1949).

Two New Basic Chromosome Numbers in the Genus *Pennisetum*

Two basic chromosome numbers, 7 and 9, have so far been reported for members of the genus *Pennisetum*, which belongs to the tribe Paniceae of Gramineae[1]. We recently recorded the somatic chromosome numbers 10 and 32 in the species *Pennisetum ramosum* C. Sm. and *P. massaicum* Stapf., which suggests two additional basic numbers, 5 and 8, for this genus. Both *P. ramosum* and *P. massaicum* are natives of tropical Africa and are perennials with profusely branched culms. Both possess all the key characters of the genus *Pennisetum*. Thus, the spikelets are solitary and are surrounded by an involucre of bristles that are free except at the very base. The first glume is shorter than the spikelets; the second glume is almost equal to the sterile lemma in size and the fertile lemma is smooth with a thin margin enclosing the palea.

In the somatic complement of *P. ramosum* one pair of satellited chromosomes was seen and the centromeres in all the chromosomes were either median or sub-median (Fig. 1). At diakinesis and metaphase I of meiosis in microsporocytes, there were five bivalents (Fig. 2). One plant was heterozygous for an inversion leading to the formation of a dicentric bridge and an acentric fragment at anaphase I (Fig. 3). Pollen and seed fertility were high (more than 95 per cent) in all the other plants. Hrishi[2] has considered this species to be synonymous to *P. polystachyon* Shult. ($2n = 54$). From the present data, this view would seem to be untenable.

Besides normal bivalents, quadrivalents, trivalents and univalents occurred at diakinesis and metaphase I of meiosis in *P. massaicum*. The mean frequency per cell of such configurations at metaphase I was $0{\cdot}85_{IV} + 0{\cdot}125_{III} + 13{\cdot}625_{II} + 0{\cdot}975_{I}$ (average of forty cells). The maximum number of quadrivalents per cell was five. Various irregularities like unequal disjunction of chromosomes, second-division restitution and sporadic abnormalities were observed during the subsequent stages of microsporogenesis. 74 per cent of pollen was stainable.



Figs. 1–3. *P. ramosum* ($2n = 10$). Figs. 4 and 5. *P. massaicum* ($2n = 32$). 1, Somatic chromosomes; 2, metaphase I of meiosis (5 bivalents); 3, anaphase I with a dicentric bridge and an acentric fragment; 4, metaphase I (2 quadrivalents and 12 bivalents); 5, metaphase II with 16 chromosomes at either pole

Seed setting was poor. It seems likely that this plant is a segmental allo-tetraploid.

The existence of a *Pennisetum* species with $2n = 10$ suggests that 5 is the original basic number in this genus and that 7, 8 and 9 have all been derived from it since. The results would further support the view that 5 is the primary basic chromosome number for all Gramineae.

We are indebted to Dr. B. P. Pal and Dr. S. M. Sikka for their interest and advice.

M. S. Swaminathan
Joginder Nath
Indian Agricultural Research Institute,
New Delhi, 12.
Aug. 22.

[1] Darlington, C. D., and Wylie, A. P., "Chromosome Atlas of Flowering Plants" (George Allen and Unwin, Ltd., 1955).
[2] Hrishi, N. J., *Genetica*, **26**, 280 (1952).

A Mutation to Caracul in the House Mouse

In an inbred line containing no hair-waving factors, but segregating for polydactyly (*py*), leaden (*ln*), and jerker (*je*), mating 19/291 threw one phenotypically wavy animal (19/291.488*b*). She appeared in the first litter and was classified as *py ln je*. As there is no source of this combination of factors in the Department other than line 19, her genotype precludes the possibility of accidental misplacement from some other wavy-bearing stock.

Mating 19/291 continued to breed, producing a total of twenty-three offspring, all of which segregated as expected for the line factors. Their coats and vibrissæ were carefully examined and, with the exception of 488*b*, were found to be completely normal (straight). Thus there is nothing genetically unusual in the mating save the production of the mutation; it seemed most probable that this was dominant and that it occurred in one or other member of the mating and not in a more remote ancestor.

The mutant doe was mated to a buck from another inbred non-wavy stock, and produced seven wavies and eight normals, confirming the dominance of the mutation.

These fifteen progeny and their descendants were used in various crosses (Tables 1 and 2).

Table 1. Segregation of the Mutant Gene

	Wavy	Normal	Total	χ^2
Backcrosses	68	53	121	χ^2 (1 : 1) = 1·8595
Intercrosses	22	10	32	χ^2 (3 : 1) = 0·6667
Outcrosses	57	0	57	

Table 2. Linkage Test with Naked (*N*)

Repulsion backcrosses: wavy/*N* ♀♀ × ++ ♂♂

Wavy	+	Wavy	+	Total	Recombination fraction
+	+	Naked	Naked		
40	3	1	46	90	4·4444 ± 0·0217%

The ratios in Table 1 show as a whole a satisfactory agreement with those expected from the segregation of a single dominant factor. However, the intercross ratio is nearer a 2 : 1 than a 3 : 1. This suggests that the mutant gene is lethal when homozygous. To test this possibility several wavies from the intercrosses were mated with normals. Two of them produced no normals out of fifty-seven (see Outcrosses in Table 1). These must have been homozygotes and thus their non-lethality is demonstrated.

The test with Naked (*N*) (Table 2) proves the mutation to be closely linked with it, the recombination fraction being 4·4444 per cent. This is not in good agreement with the value for the linkage of Caracul (*Ca*) and Naked obtained by Mallyon[1] for female gametogenesis, namely, 1·5200 ± 0·0062 per cent. In spite of this discrepancy, which may be due to environmental or to genetic differences between Mallyon's and my own stock, it appears likely that the mutation is, in fact, Caracul. But the possibility that it is a closely linked mimic is being tested.

Maureen MacNeil
Department of Genetics,
University of Cambridge.
Sept. 20.

[1] Mallyon, S. A., *Nature*, **168**, 118 (1951).

A New Mechanism for Amide Hydrolysis

Previous work on acid-catalysed amide hydrolysis has indicated that the reaction is bimolecular: in the rate-determining step the conjugate acid of the amide is attacked by a water molecule[1]. This conclusion is derived from three types of evidence. It has been shown that in concentrated aqueous acid solutions the rate of hydrolysis of a number of simple amides increases with the proportion of water in the solvent[2]; that polar substituents in the acyl part of the amide molecule have very little effect on the rate[3]; and that the rate is substantially diminished by groups, for example, *ortho* substituents in benzamides, which shield the reaction centre from attack by other molecules[3,4].

To determine whether or not there exist conditions under which unimolecular hydrolysis occurs, we have hydrolysed suitably substituted amides in an acid solvent (95–100 per cent sulphuric acid) which possesses good ionizing properties but contains little free water, and which is therefore favourable to unimolecular, but unfavourable to bimolecular, hydrolysis. A selection of the amides studied, together with the kinetic results, is given in Table 1.

Table 1

Result	Amide	Solvent	Temperature	First-order rate constant (10^3 min.$^{-1}$)
1	Acet-3.5-dinitroanilide	100 per cent sulphuric acid	65°	6·0
2	,,	97·2 per cent sulphuric acid	65°	4·5
3	,,	94·9 per cent sulphuric acid	65°	3·3
4	,,	100 per cent sulphuric acid	60°	3·5
5	Propion-3.5-dinitroanilide	,,	60°	9·6
6	Chloracet-3.5-dinitroanilide	,,	90°	< 0·1
7	Benz-2.4-dinitroanilide	,,	8°	6
8	4-Nitrobenz-2.4-dinitroanilide	,,	50°	4·4
9	2-Nitrobenz-2.4-dinitroanilide	,,	8°	6

These results have exactly opposite features to those obtained for the amides previously studied: first, the rate of hydrolysis decreases as the proportion of water in the solvent is increased (cf. results 1, 2 and 3); secondly, polar substituents in the acyl group greatly affect the rate (cf. results 4, 5 and 6; 7 and 8); and thirdly, *ortho* substituents cause steric acceleration (cf. results 7, 8 and 9). The results are, however, completely consistent with the unimolecular mechanism:

$$R'CONHR + H_2SO_4 \overset{\text{Fast}}{\rightleftharpoons} R'C\overset{+}{O}NH_2R + HSO_4^-$$

$$R'CO\text{—}\overset{\downarrow}{\overset{+}{N}}H_2R \xrightarrow{\text{Slow}} R'CO^+ + RNH_2$$

the slow step being followed by rapid conversion of the amine to its conjugate acid, and of the acyl ion to the corresponding carboxylic acidium ion[5].

A fuller account of this work will be published later.

J. A. Duffy
J. A. Leisten

Department of Chemistry,
University of Sheffield. Sept. 13.

[1] Ingold, C. K., "Structure and Mechanism in Organic Chemistry", 784 (Bell, 1953).
[2] See, for example, Taylor, J. W. J., *J. Chem. Soc.*, 2741 (1930).
[3] Reid, E. E., *Amer. Chem. J.*, **21**, 284 (1899); **24**, 397 (1900). Meloche, I., and Laidler, K. J., *J. Amer. Chem. Soc.*, **73**, 1712 (1951).
[4] de Roo and Bruylants, A., *Bull. Soc. chim. Belges.*, **63**, 140 (1954).
[5] Leisten, J. A., *J. Chem. Soc.*, 298 (1955); 1572 (1956).

Detection by Paper Electrophoresis of the Protein Denaturation in Heat-inactivated Serum for the Complement Fixation Reaction

In seeking the mechanism to explain an apparent procomplementary activity to canine complement of canine serum activated at 56° C. for 30 min., it was observed that the same serum was anticomplementary if inactivated at 62° C. instead of 56° C.

Wiggin[1] suggested that the anticomplementary action of serum depends on the relationship between the protein ratio in the serum being tested and that in the serum being used as a source of complement. Since in the above case both the serum and complement originated from the same animal, experiments were designed to find out whether serum inactivation at 62° C. affected the protein ratio.

Hæmoglobin-free sera which were obtained from healthy adult dogs were used throughout the present work. The sera were clarified by centrifugation at 3,500 r.p.m. and pooled. Fresh or heated (at 56° C., 62° C. or 65° C.) samples of the serum-pool were applied in 0·01 ml. amounts to Whatman No. 1 filter paper strips for electrophoretic separation of the proteins. The electrophoresis equipment in use was *X*118 'EEL' (Evans Electroselenium, Ltd.). The buffer solution was 30·0 gm. sodium barbitone, 19·5 gm. sodium acetate (hydrated) and 205·0 ml. N/10 hydrochloric acid (these were made up to 3 litres of distilled water). The electrophoresis proceeded in two baths (total 12 strips) for 29 hr. at a current of 0·75 m.amp. per strip. Paper strips were stained with 0·25 per cent bromphenol blue and 95 per cent ethanol saturated with mercuric chloride. Quantitative evaluation of proteins on the paper was by direct photometry of the strip.

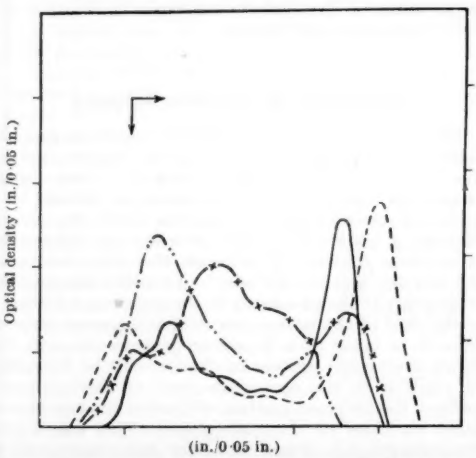


Fig. 1. Paper electrophoresis of canine serum either fresh (full line) or heated for 30 min. at different temperatures (broken lines): – – – –, 56° C.; —×—×—, 62° C.; –·–·–·– 65° C. Arrows indicate site of application and direction of run

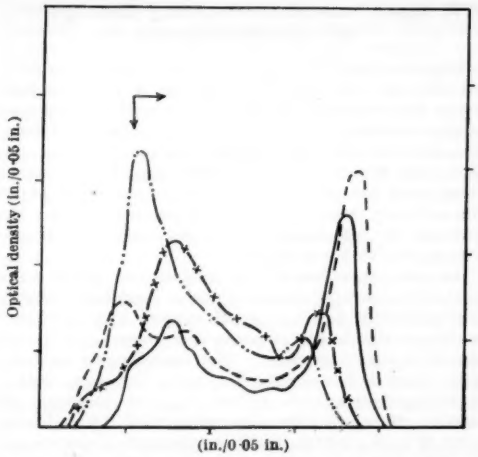


Fig. 2. Paper electrophoresis of canine serum either fresh (full line) or heated for 1 hr. at different temperatures (broken lines). – – – –, 56° C.; —×—×—, 62° C.; —·—·—·—, 65° C. Arrows indicate site of application and direction of run

Fig. 1 shows that heating of canine serum markedly affected electromigration of the protein particles. It is apparent that after heating serum at 56° C. for 30 min. the protein particles migrated faster if compared with unheated serum. Heating of serum at 62° C. or 65° C. for 30 min. reduced considerably the electromigration. Here the protein was strongly adsorbed in the paper and formed patterns which were entirely different from those obtained with unheated serum. The protein denaturation, as shown in Fig. 2, was more marked in samples of serum which were heated at the above temperatures for 1 hr. instead of 30 min.

These experiments suggest that the serum protein can be denatured by temperatures which are commonly used for inactivating serum for the complement-fixation reaction. Detection by paper electrophoresis of protein denaturation at these temperatures has not hitherto been described. Secondly, it seems that, as a function of the serum protein, the procomplementary or anticomplementary activity probably depends on the electric charge on the protein particle in the serum being tested.

A full account of these and related experiments will be published elsewhere.

N. M. Larin

The Animal Health Trust,
Virology Laboratory,
Canine Research Station,
Kennett, Nr. Newmarket.
Sept. 20.

[1] Wiggin, N. J. B., Ph.D. thesis, Department of Pathology, University of Cambridge (1955).

A Light Source for locating Œstrogens on Chromatograms

As part of an investigation at this Station into the reproductive physiology of sheep, a suitable light source was required for detecting traces of œstrogens on paper chromatograms of blood extracts. Œstrogens have an absorption maximum near 280 mμ, and light near this wave-length gives maximum contrast when used for photographing them on filter paper. The mercury-vapour lamp is commonly used for this purpose, but its emission in this region is weak and a train of filters is required.

On the other hand, the magnesium spark emits most of its photographically active radiation between 2791 and 2803 A., and a spark system assembled from readily available components has proved simple and convenient in operation. The transformer was of a type used commercially for neon lighting, with a secondary rating of 15,000 V., 30 m.amp., the 0·0025 μF. condenser was assembled by soldering forty 0·1 μF., 500 V. radio condensers in series and the 0·01 μH. coil consisted of seven turns of 14-gauge copper wire on a 3-in. diam. 'Tufnol' tube. The electrodes were made by winding two helices of magnesium ribbon about 1 cm. in diameter held approximately 6 mm. apart.

Photographs taken through No. 1 Whatman filter paper in contact with Ilford reflex document paper using 10 sec. exposure at 70 cm. enabled spots down to 1 μgm. œstrone/sq. cm. to be detected. Using a 4-cm. filter of nickel sulphide and cobalt sulphate to reduce undesirable radiation failed to give any apparent increase in sensitivity.

Although the spark system is run in air, the electrodes can be operated continuously for periods up to one minute without igniting.

D. D. Perrin

Ruakura Animal Research Station,
Hamilton, New Zealand.
Sept. 20.

A New Detector for Vapour Phase Chromatography

Vapour phase chromatography has been used with great success in these laboratories for the analysis of the products of reactions in the gas phase. By using a thermal conductivity detector it has been possible to estimate amounts of product of the order of 10^{-8} mole; but this was the lowest limit which could be reached. In certain cases, however, it became necessary to detect 10^{-12} mole of a substance. The detector described below has been developed to meet this requirement. It is of wide applicability and is easily constructed.

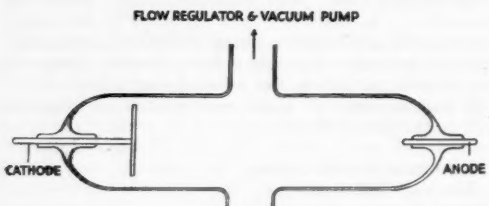


Fig. 1. Glow-discharge detector

Use is made of the fact that the voltage existing across a normal gaseous discharge is a function of the type of gas used. This voltage changes by several volts with the introduction of a minute amount of impurity into the gas. The detector consists of a small platinum disk cathode and a tungsten wire anode (Fig. 1) forming one arm of a Wheatstone bridge which is supplied with 900 volts from a stabilized d.c. source. The bridge is balanced with carrier gas flowing through the detector at a pressure sufficiently low to produce a normal glow discharge between the electrodes. Compounds eluted from the column cause a voltage change across the detector which is measured by a recording potentiometer. Fig. 2 shows a recording of the constituents separated from 10^{-10} mole of petroleum ether (40–60°) on a 4-ft. column of 'Celite' and amyl phthalate. Details of the technique will be published later.

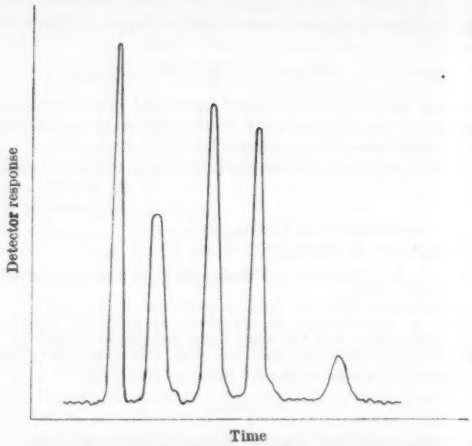


Fig. 2. Detection of components of paraffin mixture

J. Harley
V. Pretorius

Department of Physical Chemistry,
University of Pretoria.

Definition of Chromatography

The essence of the classical chromatographic method of Tswett[1] is presented by Ratchinsky[2] in the form of the following definition: "Any liquid or gaseous mixture of the substances is divided into its components during the process of its movement through a layer of sorbent, if there are differences in sorbtion interaction between the components of the mixture and the sorbent". I believe the relative movement of the phases to be the important feature; in the case of the movement of the dispersed sorbent through a layer of a liquid or gaseous mixture the chromatographic process of Tswett will be inverted. In relation to the aggregate state of the dispersed sorbent the inverted method of Tswett thus embraces three varieties of chromatography: (1) suspension chromatography—when the solid dispersed particles of the sorbent settle or rise through the liquid or gaseous mixture[3,4]; (2) emulsion chromatography—when the dispersed drops of liquid move through the

liquid or gaseous mixture[5]; (3) foam chromatography when the dispersed bubbles move through the liquid mixture[6,7].

It follows that all the varieties of chromatography can be divided into two groups: the group when the liquid or gaseous mixture flows through the layer of the sorbent (classical method of Tswett) and the group when the dispersed sorbent settles or rises through a liquid or gaseous mixture (inverted method of Tswett).

S. G. Mokrushin

Laboratory of Colloid Chemistry,
Urals Polytechnical Institute,
Sverdlovsk, U.S.S.R.
July 29.

[1] Tswett, M. S., "Chromatographic Adsorption Analysis". Selected Papers, edit. by Richter, A. A., and Krasnoselskaja, T. A., 141 (Acad. Sci. U.S.S.R. Press, 1946).
[2] Ratchinsky, W. W., The Works of the Commission for Analytical Chemistry, YI (IX), 21 (Acad. Sci. U.S.S.R. Press, 1955).
[3] Aleskovsky, W. B., Reports of Scientific Technical Conference of 1955. The Leningrad Technological Institute, 27 (Stateschemical Press, Leningrad, 1955).
[4] Mokrushin, S. G., *Kolloid Zhur* (in the press).
[5] Shedlovsky, L., in "Chromatography", Collected Papers, 176, ed. by Dubinin, M. M. (Acad. Sci. U.S.S.R. Press, 1949).
[6] Mokrushin, S. G., Collections of Scientific Papers of the All-Union Mendeleev Chem. Soc., No. 2, 26 (1953).
[7] Yermolenko, N. F., *Discuss. Farad. Soc.*, **18**, 150 (1954).

Cathodic Protection of Iron

It has been frequently suggested that the cathodic protection of iron in chloride solutions is due to the depression of its potential to or below the open-circuit potential of the local anodes[1,2]. However, in neutral solutions containing dissolved oxygen the open-circuit potential of the local anodes cannot be measured directly without assuming the previous statement to be true. Nor can it be calculated from the Nernst equation, since the ferrous ion activity in equilibrium with hydrated ferric oxide is unknown. Since the formation of hydrated ferric oxide may be represented by an equation such as

$$4\,Fe^{++} + 8\,OH' + O_2 = 4\,FeO.OH + 2H_2O$$

it is implicit that the open-circuit potential of the local anodes should become more electronegative with increasing *p*H.

Valuable information on the mechanism of cathodic protection may be obtained by impressing constant currents using an inert anode and measuring the change in potential of iron cathodes with time. Specimens of iron measuring $2{\cdot}5 \times 0{\cdot}5 \times 0{\cdot}088$ cm. the composition of which has been given previously[3] were decreased in benzene, immersed in 0·1 *N* hydrochloric acid for 1 min., rinsed rapidly in water, dried and stored in dry air for 24 hr. Individual specimens were subjected to cathodic polarization in 100 ml. of sodium chloride solution at current densities of 20 and 40 microamp./sq. cm. using an inert platinum anode. Impressed currents completely protected the iron specimens against corrosion.

Fig. 1 shows potential–time curves on the standard hydrogen scale for the iron cathodes at the two current densities in 1 *N* sodium chloride (*p*H = 6·2) and at 20 microamp./sq. cm. in 1 *N* sodium chloride with the *p*H adjusted to 8·9 (potentials are expressed on the standard hydrogen scale). Fig. 1 also shows the potential–time curve for uncoupled iron in 1 *N* sodium chloride.

Although the open-circuit potential of the local anodes on the iron is unknown, it must certainly be more electronegative than the corrosion potential of iron in the same solution. At 20 microamp./sq. cm. at initial *p*H values of 6·2 and 8·9, potential–time curves for cathodically polarized iron are clearly very erratic, even though the potential of the platinum anode remains completely steady. The form of the curves strongly suggests a process of alternate oxide film breakdown and repair. Separate experiments under similar conditions on iron cathodes oxidized to the first-order violet interference colour show no overall disappearance of colour in 24 hr. and demonstrate that any oxide film on the cathode is not cathodically reduced to soluble ferrous ions at an appreciable rate[3]. After several hours at both *p*H values, the potentials of the iron cathodes become more noble than that of unpolarized iron, and yet they still remain completely passive. Clearly, under these conditions the potentials of the iron cathodes are more noble than any value that may be attributed to open-circuit potential of the local anodes. Furthermore, the curve at *p*H = 8·9 is displaced to more noble potentials than that at *p*H = 6·2, even though increasing *p*H should move the open-circuit potential of the local anodes in the more electronegative direction.

At 40 microamp./sq. cm. and an initial *p*H value of 6·2 the potential–time curve is first fairly steady. Separate experiments on iron cathodes oxidized to the first-order violet interference colour show that under these experimental conditions the oxide film suffers cathodic reduction to soluble ferrous ions with an accompanying disappearance of colour within 5 min. Probably the higher impressed current results in partial oxygen depletion at the cathode. Since recent work (Oswin, H. G., private communication) has demonstrated that α-ferric oxide films may be

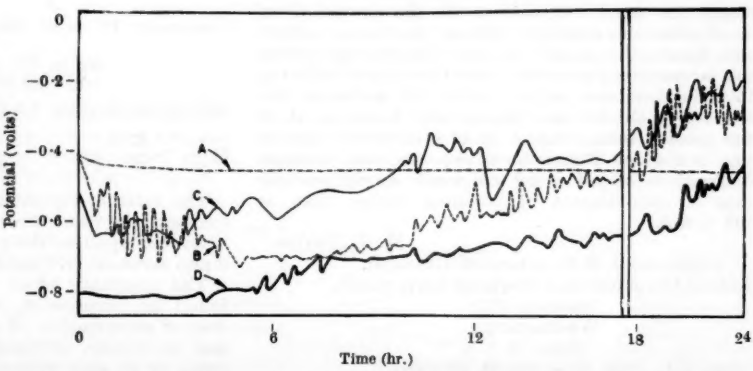


Fig. 1. Potential–time curves for cathodically polarized and unpolarized iron in 1 *N* sodium chloride at 25° C. *A*, Corroding iron—no external polarization; *B*, iron polarized cathodically at 20 microamp./sq. cm., *p*H = 6·2; *C*, iron polarized cathodically at 20 microamp./sq. cm. *p*H = 8·9; *D*, iron polarized cathodically at 40 microamp./sq. cm., *p*H = 6·2

cathodically reduced in deaerated solutions at *p*H values up to 11·0, it is not unreasonable to expect that reduced oxygen content due to the higher impressed current would favour reduction of any initial oxide film on the iron. However, as the *p*H of the solution around the cathode increases with prolonged cathodic polarization, the efficiency of cathodic reduction of the oxide probably decreases and alternate film repair and breakdown is observed after 4 hr. As film repair gradually achieves ascendancy the potential of the cathodically polarized iron again becomes more noble than that of unpolarized iron.

It is believed that these results indicate that the present theory of cathodic protection is applicable only to a limited number of cases. Clearly, the potential of iron may be depressed enough to make rapid corrosion unlikely from the thermodynamic point of view. Under such conditions the initial oxide film on the iron must be cathodically reduced. If the potential is maintained at the depressed value, perhaps by coupling an active zinc or magnesium anode, the oxide film will not re-form.

However, many cases of cathodic protection must exist where prevention of corrosion can be attributed to an entirely different mechanism. These would include the protection of iron by coupling to high-purity aluminium, by the use of impressed current densities less than 40 microamp./sq. cm., and by coupling to zinc the potential of which had been somewhat ennobled by the formation of corrosion products. In these cases the oxide film is not cathodically reduced. Instead, the function of the cathodic current is probably to reduce the rate at which iron ions leave the metallic lattice. The kinetics of the competing reactions of corrosion and protective oxide film formation are thus disturbed, and the evidence from Fig. 1 indicates that oxide will progressively cover the surface and help to prevent further egress of iron ions from the metallic lattice. During the gradual build-up of a protective oxide film, localized film breakdown, either due to localized reduction of the film or else to undermining by chloride ions, occurs as evidenced by the rapid potential fluctuations. However, these active areas are evidently later repaired by oxygen in solution as the potential continues to move in the noble direction and passivity is maintained.

This kinetic mechanism of cathodic protection is essentially similar to a recent mechanism proposed for anodic inhibition of the corrosion of iron[4] when the inhibitor reduces the rate at which iron leaves the metallic lattice, thereby permitting the formation of a highly protective film of γ-Fe_2O_3. It is implicit that higher initial *p*H values of the electrolyte should also favour the development of the passive state, and it is of interest to note in Fig. 1 that at 20 microamp./sq. cm. the potential fluctuations at *p*H = 8·9 are much slower and the rate of ennoblement of potential higher than at *p*H = 6·2.

M. J. Pryor

Department of Metallurgical Research,
Kaiser Aluminum and Chemical Corporation,
Spokane 69,
Washington.

Sept. 18.

[1] Hoar, T. P., *Trans. Farad. Soc.*, **30**, 480 (1934).
[2] Mears, R. B., and Brown, R. H., *Trans. Electrochem. Soc.*, **74**, 519 (1938).
[3] Pryor, M. J., and Evans, U. R., *J. Chem. Soc.*, 1259 (1950).
[4] Pryor, M. J., *J. Electrochem., Soc.*, **102**, 163 (1955).

A Quantity Analogous to Trouton's Constant

It is well known that van der Waals, in conformity with the theory of the corresponding states, stated the relation:

$$\ln \frac{p_c}{p} = A \frac{T_c - T}{T} \quad (1)$$

where A is a universal constant.

Such relation is also the result of the application, to the vaporization phenomenon, of Clausius and Clapeyron's equation, integrated at constant heat of vaporization (λ) between the critical temperature (T_c) and another temperature (T) below the critical one:

$$\ln \frac{p_c}{p} = \frac{\lambda}{R}\left(\frac{1}{T} - \frac{1}{T_c}\right) = \frac{\lambda}{RT_c}\left(\frac{T_c - T}{T}\right) \quad (2)$$

Comparing the two relations (1) and (2) we obtain:

$$A = \frac{\lambda}{RTc} \quad (3)$$

Van der Waals gives $A = 6{\cdot}9$. This value applied to equation (1) gives, generally, good results; 6·9 is, however, a median value, and the figure after the decimal point varies with different substances and also at different temperatures.

On the other hand, I have shown[1] that, for normal liquids, the following equation of state is valid (per mole):

$$3 N_A^{1/3} V_M^{2/3} \gamma = K(T_c - T) \quad (4)$$

where N_A is Avogadro's number; V_M is molecular volume; γ is superficial tension; and T_c is critical temperature.

The constant K, as well as Eötvös's constant, which is given by the relation $\frac{V_M^{2/3}\gamma}{(T_c - T)}$, proves to be a universal constant, independent of temperature.

As Eötvös's constant corresponds, for normal liquids, to a median value of 2·12 ergs, the value of K is found from the following relation:

$$K = 3 N_A^{1/3} \times 2{\cdot}12 \times 2{\cdot}389 \times 10^{-8} = 12{\cdot}86 \text{ cal.} \quad (5)$$

where $2{\cdot}389 \times 10^{-8}$ is the factor for converting ergs into calories.

I have also shown[2] that:

$$RT \ln \frac{p_c}{p} = 3 N_A^{1/3} V_M^{2/3} \gamma \quad (6)$$

Comparing (6) with (4), we obtain:

$$RT \ln \frac{p_c}{p} = K(T_c - T)$$

and, upon dividing by RT:

$$\ln \frac{p_c}{p} = \frac{K}{R}\frac{T_c - T}{T} = \frac{12{\cdot}86}{1{\cdot}98} \cdot \frac{T_c - T}{T} = 6{\cdot}5 \frac{T_c - T}{T} \quad (7)$$

The relation (7) shows that the van der Waals's constant, the value of which is 6·5, is a dimensionless quantity, equal to the relation between the normal-liquid constant (K) and the ideal-gas constant (R).

The constancy of A that, as previously said, is found by experiment, requires either (*a*) the mol. heat of vaporization (λ) and R (constant for the ideal gas) to remain unchanged with temperature (ideal case), or (*b*) such quantities to change in a way that should keep their relation to one another constant.

In the latter case the behaviour of the vapour will not be that of the ideal gas, and we shall have to

substitute for R the value $\frac{p(v_g - v_l)}{T}$, where p is the equilibrium pressure at temperature T, and v_g and v_l respectively the gas volume and the liquid volume per mole at such temperature.

Therefore relation (3) may be written:

$$A = \frac{T\lambda_s}{p(v_g - v^l)T_c} = \frac{\lambda}{RT_c}$$

where λ_s represents the experimental heat of vaporization.

Taking $(v_g - v_l) = \Delta v$, we obtain:

$$A \frac{T_c}{T} = \frac{\lambda_s^s}{p\Delta v} \qquad (8)$$

The above equation shows that the value of the relation $\frac{\lambda_s}{p(v_g - v_l)}$ is the same for all substances when they are in a corresponding state.

In particular, for the normal boiling point (T_e) ($p = 1$ atm.) putting $T_c/T_e = 3/2$, we obtain, measuring λ in calories, Δv in litres and p in atm.:

$$A \cdot \frac{3}{2} = \frac{1}{24{\cdot}12} \cdot \left(\frac{\lambda_s}{\Delta v}\right)_{Te} = 6{\cdot}5 \cdot \frac{3}{2} \simeq 10 \qquad (9)$$

where 24·12 is the equivalent in calories of the litre atmosphere.

The universal constant, derived in this way, corresponds to half Trouton's constant (λ_s/T_e), nearly.

Equation (9) shows, therefore, that at the normal boiling point, the heat of vaporization is for all normal liquids about ten times as much as the absorbed heat, during the evaporation, required to do the external work (given by $p\Delta v$, where $p = 1$ atm.).

Further, since

$$\left(\frac{\lambda_s}{T}\right)_{Te} \simeq 20 \quad \text{and} \quad \frac{1}{24{\cdot}12} \cdot \left(\frac{\lambda_s}{\Delta v}\right)_{Te} \simeq 10$$

we have also:

$$24{\cdot}12 \left(\frac{\Delta v}{T}\right)_{Te} \simeq \frac{20}{10} \simeq 2 \qquad (10)$$

A. Giacalone

Catania-Istituto di Chimica Fisica,
Università di Catania.

June 6.

[1] *Ric. Sci.*, **19**, 553 (1949).
[2] *Gazz. Chim. Ital.*, **77**, 448 (1947).

A Function Multiplier

We are at present developing, for use in a repetitive electronic differential analyser of 1 per cent nominal accuracy, a function multiplier which shows great promise in simplicity and electrical characteristics.

The principle of multiplication is based on a geometrical system, namely, a rectangular area which is deflected relative to a system of rectangular axes. The axes divide the rectangular area into four rectangles, A, B, C and D, which are equal in area in its undeflected position. The areas in the four quadrants are summed according to the algebraic expression:

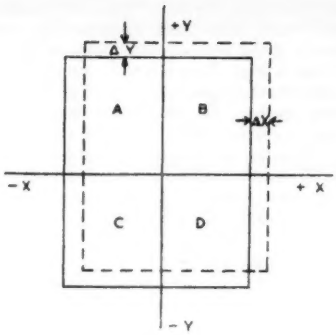


Fig. 1

$$R = A - B - C + D \qquad (1)$$

so that for $A = B = C = D$
$R = 0$

If the total rectangular area is displaced a distance Δx in the x direction and Δy in the y direction as shown in Fig. 1, the resultant area as given by the expression (1) above is:

$$R = 4\ \Delta x\ \Delta y$$

Inspection will show that this results in a four-quadrant multiplier yielding the correct algebraic sign of the product and being zero when either Δx or Δy is zero.

A suitable rectangular area was produced on the screen of a cathode-ray oscillograph tube, by defocusing the beam sufficiently to allow the deflecting plates to act as a rectangular aperture shielding the rest of the electron beam. The pattern is deflected by applying deflecting voltages in the normal way, the deflecting plates thus having the dual role of mask and deflecting system.

The area in each quadrant is evaluated by measuring the total light emitted from that quadrant, uniform illumination being produced by saturating the phosphor over the total rectangle.

The light measurement is done by 'piping' the light along four rectangular polished 'Perspex' light-guides on to the photo-cathodes of four 931-A photomultipliers. The schematic diagrams of Fig. 2 (left and right) illustrate the method used. This method yields high optical efficiency, and the guide ends nearest the cathode-ray oscillograph face are machined to fit the curvature of the tube. The light at the photomultiplier end is diffused and is proportional to the illuminated area exposed to the input end of the guide. The output currents of the four photomultipliers are summed in a simple feedback adder, the required negative signs for B and C being obtained by suitably connecting the photomultiplier dynodes.

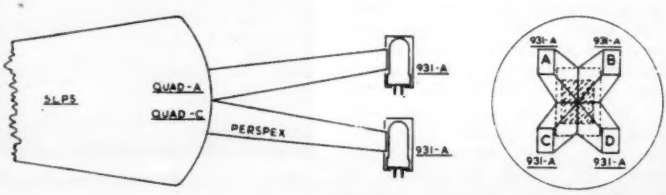


Fig. 2

In an experiment a Du Mont type 5*LP*5 cathode-ray oscillograph tube was used because the deflecting plates gave a good rectangular pattern and the *P*5 phosphor has a high frequency response. Excellent zero adjustment characteristics were experienced and from interpretation of multiplied wave-shapes the linearity and accuracy were deduced to be good. The frequency response is potentially good since all the individual elements used have wide band-widths.

A unit is now being engineered with the view of detailed tests and incorporation in a differential analyser.

I wish to express my appreciation to the President of the Council for Scientific and Industrial Research for permission to publish this communication.

J. D. N. van Wyk

Electrotechnology Subdivision,
National Physical Laboratory,
South African Council for
Scientific and Industrial Research,
Pretoria.
Aug. 9.

Liquid Crystals of Montmorillonite

If a section of a dry sodium montmorillonite film is placed in a solution of sodium chloride it will swell parallel to the *c*-axis, the swelling increasing as the salt concentration is reduced, until at a sufficiently low concentration (about *N*/100) complete dispersion occurs. This swelling has now been observed under a microscope. Fractions less than 2μ from samples of Wyoming and Dakota bentonites were washed with *N* sodium chloride and then freed from chloride by dialysis through a cellulose casing, keeping the *p*H of the dialysate about 7·0 by adding dilute sodium hydroxide. An aliquot of the suspended clay was then slowly dried to form an orientated flake about 0·01 cm. thick.

Sections about 0·3 mm. thick were cut with a scalpel from the prepared flakes, placed on a glass slide and a few drops of *N*/30 sodium chloride added. The swelling was observed with the flake on its side, that is, with the *c*-axis of the crystallites perpendicular to the axis of the microscope. The swollen gel showed no structure with ordinary light, but under crossed nicols, on rotating the gel, instead of the extinction being sharp at 90° intervals as each of the nicols in turn became parallel to the *c*-axis, irregular dark bands were observed parallel to the *c*-axis (Fig. 1). The angle between the appearance of the first bands through maximum extinction to the disappearance of the bands was about 20°. The bands appeared independent of the direction in which the section was cut from the flake. The bands were sharpest with very thin gels (birefringence colour, first-order white) and were visible only with the microscope focused on the gel (in particular, with thick gels only on the upper surface of the gels). Between parallel nicols the bands reappeared at an angle of 45° to their original direction. A similar type of band formation has been observed with liquid crystals of tobacco mosaic virus[1]. If the concentration of sodium chloride surrounding the gel was reduced below the flocculating concentration, the bands increased in length and finally disappeared when the specimen became too thin to show birefringence colours. There was no evidence of structure if the flake was viewed parallel to the *c*-axis. The expanded gel from a flake made with the clay fraction less than 0·5μ gave slightly more regular bands, there being fewer of the occasional very wide bands present in the gels of less than 2μ particles. Sections from a flake dried only to the 'cheesy' condition gave rise to bands on immersion in sodium chloride, but the angle over which the bands appeared was increased to 70°.

A flake was also prepared from a montmorillonite suspension to which a small quantity of a cationic stabilizing agent (*CTAB*) had been added. In the swollen gel the non-expanded crystallites are visible perpendicular to the bands because of their higher birefringence (Fig. 2).

Ross and Hendricks[2] deduced that in dry flakes of sodium montmorillonite the individual platelets or crystallites are arranged approximately parallel to the surface of the flake and randomly orientated perpendicular to this plane. The average width of the bands, about 2μ, is much greater than the diameter of the individual crystallites, 9·6 A. thick, many of which are known to be about 1500 A. in diameter. The length of each band is not well defined but is usually greater than 150μ in the expanded gel, corresponding to an unexpanded thickness of clay of 5μ. It is inferred that in the dry flake the crystallites are stacked parallel to the *c*-axis to form crystals of height at least 5μ and diameter 2μ. The bands are due to the crystals not being exactly parallel to the surface of the flake, so that the optic axes of the crystals are inclined at a few degrees. The inclination of the crystals must be random, since the bands are observed irrespective of the direction in which the flake is cut. The bands would be expected to be sharpest in the very thin gels, first-order white corresponding to a thickness of dry clay of 5μ, that is, one or two layers of crystals only. From the experiment with the incompletely dried flake, it appears that during drying the crystals are formed first and that afterwards the orientation of the crystals is improved. Previous evidence of the existence of montmorillonite crystals is that (00*l*) reflexions can be obtained from powder photographs.

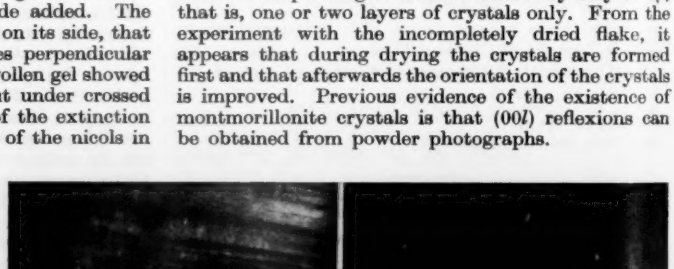


Fig. 1. Sodium Wyoming bentonite in *N*/30 sodium chloride, particles less than 2μ. × 100

Fig. 2. Sodium Wyoming bentonite + 0·5 per cent *CTAB* in *N*/30 sodium chloride, particles less than 2μ. × 100

I wish to thank Dr. H. L. Penman and A. H. Weir for helpful discussions.

W. W. Emerson

Rothamsted Experimental Station,
Harpenden, Herts.
Aug. 28.

[1] Wilkins, M. F. H., *et al.*, *Nature*, **166**, 127 (1956).
[2] Ross, C. S., and Hendricks, S. B., *U.S.D.I. Prof. Paper* 205-*B* (1945).

Noise Radiation from Tropical Thunderstorms in the Standard Broadcast Band

An objective method of measuring atmospheric noise interference to broadcasting based on subjective observations and statistical considerations has been reported[1]. Results of systematic measurements by the method in the 3 and 5 Mc./s. bands have been published[2,3]. It has been shown that these results can be satisfactorily explained on the basis of the available data on lightning discharges[4], the distribution of thunderstorm days[5], the growth and decay of thunderstorms[6], and the laws of propagation. For this purpose, the available data on lightning discharges have been utilized to deduce an idealized statistically valid representation of a typical flash as it occurs in a tropical thunderstorm[4]. It is found that

$$P = 45/f^2 \qquad (1)$$

where P is the power in watts and f is the frequency in Mc./s.

The calculations are with specific reference to the band-width and time-constant characteristics of the noise meter. It has been assumed that there are three strokes to a flash and that all thunderstorms recorded by weather offices as 'thunderstorm days' radiate noise. It has, however, been clearly stated that the equation must break down for frequencies below 1 Mc./s. This statement was based partly on theoretical considerations and partly on the preliminary investigations[1]. It was therefore felt that measurements of atmospheric noise interference to broadcasting at frequencies below 1 Mc./s. would be valuable not only from the point of view of getting noise data but also for theoretical evaluations. Hence, noise measurements were carried out at 620 and 930 kc./s. at Poona for 18–23 hr. I.S.T., during 1954–56, by C. G. Khot under my direction. Occasionally, observations have also been taken for 12–24 hr. The results have been analysed and the noise data deduced as usual.

Estimates of noise were made as usual by using the power given by equation (1). These estimates were invariably found to be higher than the measured values. Further, our study of individual thunderstorms simultaneously at a number of frequencies had indicated something abnormal at frequencies below 1 Mc./s. In order, therefore, to attempt a possible explanation of the results, the lightning discharge data and the original theoretical calculations were re-examined. It appears that the discharges within the cloud or into the air do not radiate any significant power at frequencies below 1 Mc./s., that is, noise radiation at frequencies below 1 Mc./s. appears to arise entirely from thunderstorms in which the discharge strikes the ground. Further, even in these cases, it is only the stepped leader that is responsible for the radiation of noise. There appears to be no radiation from the dart leaders.

Calculations carried out on the basis outlined above resulted in the following expression for the noise power radiated:

$$P = \frac{16 \cdot 2}{f^2} \cdot \frac{1}{1 + \dfrac{\delta^2}{4\pi^2 f^2 \cdot 10^{12}}} \text{ watts} \qquad (2)$$

δ is the constant in the expression for the exponential rise of current in the discharge.

Using equation (2) and the laws of propagation, noise values were estimated, and these appear to agree well with measured values. It appears that equation (2) holds up to 500 kc./s. or even lower. This lower limit has to be evaluated by further experiments. The higher frequency up to which the equation holds lies between 1 and 3 Mc./s. and detailed investigations in this region should prove interesting.

This communication is being published in view of its possible interest to those studying the wave-forms of atmospherics and other problems of thunderstorm electricity during the forthcoming Geophysical Year. The complete theoretical and experimental work will be published in due course elsewhere.

S. V. Chandrashekhar Aiya

L.D. College of Engineering,
Ahmedabad 9.
Aug. 22.

[1] Aiya, S. V. C., *J. Atmos. Terr. Phys.*, **5**, 230 (1954).
[2] Aiya, S. V. C., and Phadke, K. R., *J. Atmos. Terr. Phys.*, **7**, 254 (1955).
[3] Phadke, K. R., *J. Inst. Telecomm. Eng. (India)*, **1**, 136 (1955).
[4] Aiya, S. V. C., *Proc. Inst. Radio Eng.*, **43**, 966 (1955).
[5] Aiya, S. V. C., *J. Sci. Indust. Res.*, **13** A, 314 (1954).
[6] Aiya, S. V. C., Khot, C. G., Phadke, K. R., and Sane, C. K., *J. Sci. Indust. Res.*, **14** B, 361 (1955).

Temperatures in the Earth's Interior

The melting-point gradient for the Earth's mantle has been determined by Uffen[1] from Lindemann's law; the results yield an upper limit on the actual temperature. Simon[2] and Bullard[3] have made estimates, from Simon's semi-empirical fusion equation, of melting temperatures in the Earth's core, which provide a lower limit to the corresponding temperature in the liquid outer core.

In a recent paper[4], I have derived the Lindemann law from the theory of Debye and Waller for the thermal dependence of the intensity of reflexion of X-rays by a crystal. The development yields[5] a direct derivation of the Simon melting equation, which can be written

$$P_m = A[(T_m/T_{m,o})^B - 1] \qquad (1)$$

where T_m and $T_{m,o}$ are the absolute melting temperatures at pressure P_m and zero, respectively, and A is a constant. If the Earth's core is presumed to consist of iron, my results show that

$$B = (6\gamma_{m,o} + 1)/[2(3\gamma_{m,o} - 1)] \qquad (2)$$

where $\gamma_{m,o}$ is the Grüneisen constant of the solid at fusion under zero pressure. The applicability of equation (2) follows[5,6] from the fact that iron is sufficiently incompressible for osculating approximations at the origin of the fusion curve to be valid. An

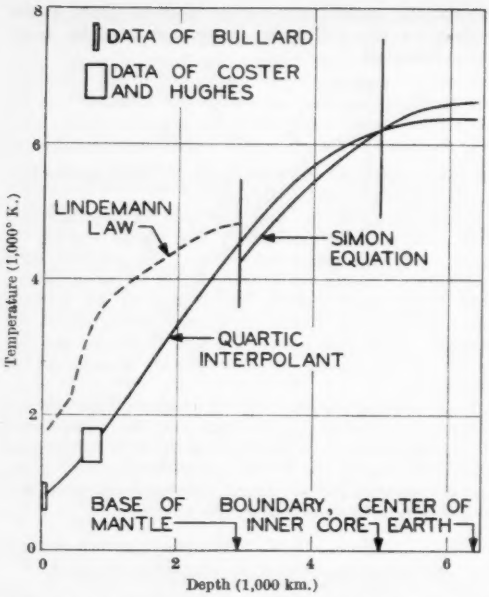


Fig. 1. The fusion temperature in the Earth's core as estimated from the Simon equation, with fusion temperatures (dashed) for the mantle from the Lindemann law (Uffen). The quartic interpolation polynomial yields an estimate of the actual temperature (rectangles and lines indicate possible limits of error)

experimentally verified theoretical relation[4], in terms of fusion parameters, for the Grüneisen constant of a solid at melting yields $\gamma_{m,0}=0{\cdot}92$, as a mean value for iron; one obtains $B=1{\cdot}9$ from equation (2). With this value of B and Simon's value[2] of A for iron, equation (1) yields the curve shown in Fig. 1 for the melting temperature in the Earth's core, when the pressure is related to the depth by values from seismic data[3]; Uffen's curve for the melting temperature (corresponding to use of the Debye frequency) in the mantle is shown also (dashed). One notes that the fusion temperature for the inner core is higher than that for the mantle at its base, so that no conflict appears with Jacobs's hypothesis[7] on the origin of a solid inner core. In evaluating B for iron, Simon and Bullard used values for the highly compressible alkali metals as a guide; correspondingly, their fusion temperatures for the core are considerably below those of Fig. 1, and are in conflict[8] with Jacobs's hypothesis.

Bullard[3] has estimated the temperature in the Earth at a depth of 35 km. as $800\pm200°$ K. The only experimental evidence on the temperature at depth is the determination by Coster[9] and Hughes (unpublished) of 1,300–1,800° K. as the temperature at which silicates show the low resistivity for a depth of 600–900 km. required by geomagnetic results. Average points from these data are shown in Fig. 1 by rectangles indicating limits of error. At the base of the mantle, computed fusion temperatures yield immediate limits to the actual temperature, which must lie between the fusion temperatures of the liquid core and solid mantle at this point. The temperature at this point will be taken as an average corresponding to the two fusion temperatures in question; possible limits of error are shown by a vertical line in Fig. 1. Further, if the inner core is solid, the fusion temperature at its boundary is the actual temperature (for inner and outer core of the same composition). The four temperatures in question can be used for constructing a quartic polynomial for the temperature as a function of depth, when one imposes the constraint that the temperature gradient vanishes at the centre of the Earth (as follows from Gauss's law). The interpolating polynomial for the temperature T in 10^3 ° K. is

$$T = 0{\cdot}773+0{\cdot}750d+0{\cdot}463d^2-0{\cdot}1148d^3+0{\cdot}00708d^4 \quad (3)$$

in terms of the depth d in 10^3 km. The coefficients are given to the figures shown, merely for proper round-off; the limits of error are given as about ±25 per cent by the limits indicated in Fig. 1. The temperatures implied are quite close to those given by Daly[10] for the greater depths in the mantle. Inasmuch as the mean temperature gradient predicted for the mantle exceeds substantially the adiabatic gradient of 0·17 deg. C./km. estimated by Verhoogen[11] for the (solid) mantle, this temperature distribution is consistent with solidification of the mantle from the base up. The mean temperature gradient (0·78 deg. C./km.) for the outer core is close to the values 0·5–0·7 deg. C./km. for the adiabatic gradient which follow from results of Birch[12].

A full account of this work (performed while I was associated with the Rand Corporation, Santa Monica, California) will appear elsewhere.

John J. Gilvarry
Research Laboratories,
Allis-Chalmers Manufacturing Company,
Milwaukee, Wisconsin.
Sept. 12.

[1] Uffen, R. J., *Trans. Amer. Geophys. Union*, **33**, 893 (1952).
[2] Simon, F. E., *Nature*, **172**, 746 (1953).
[3] Bullard, E., in Kuiper, G. P. (ed.), "The Earth as a Planet", 96–115 (Univ. of Chicago Press, Chicago, 1954).
[4] Gilvarry, J. J., *Phys. Rev.*, **102**, 308 (1956).
[5] Gilvarry, J., J., *Phys. Rev.*, **102**, 325 (1956).
[6] Gilvarry, J. J., *Phys. Rev.* (in the press).
[7] Jacobs, J. A., *Nature*, **172**, 297 (1953).
[8] Jacobs, J. A., *Nature*, **173**, 258 (1954). Uffen, R. J., and Misener, A. D., *ibid.*, **173**, 259 (1954).
[9] Coster, H. P., *Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **5**, 193 (1948).
[10] Daly, R. A., *Bull. Geol. Soc. Amer.*, **54**, 401 (1943).
[11] Verhoogen, J., *Trans. Amer. Geophys. Union*, **32**, 41 (1951).
[12] Birch, F., *J. Geophys. Res.*, **57**, 227 (1952).

Guarded-Field Ionization Chambers: a New Principle applied to both Free-Air and Thimble Versions

Taylor and Singer[1] placed a system of parallel guard wires around the inter-electrode space of a 'free-air' ionization chamber, the wires being maintained at potentials evenly graded between those of the collecting electrode and the high-voltage electrode respectively. Electrostatic field distortion (largely arising from the proximity of the earthed casing) was thereby diminished, enabling the chamber dimensions to be reduced—an important factor in a chamber designed for portability. However, the guard wires, taken together, comprise a relatively inefficient screening and field-shaping system[2], and we have investigated a guard strip system, a cross-section through the mid-plane of a typical free-air chamber incorporating this system being as shown in Fig. 1. *AA'*, *BB'*, *CC'*, etc., are the sections of rectangular metal (or graphited plastic) frames, which pass along

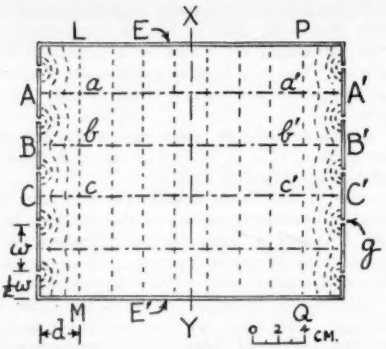


Fig. 1. Mid-plane section of free-air chamber employing guard strips

both sides of the chamber and across the ends, except for small apertures in the ends of the central one (or the central pair, as the case may be), permitting the passage of the X-ray beam. The width w of each of the frames is large compared with the gap g between consecutive frames. Thus w might be, say, 4 cm., and g 4 mm. only. The upper and lower electrode systems E and E' have an edging of width $\frac{1}{2}w$, as shown. Equal potential differences are maintained across all the gaps g. It is easily seen that in these circumstances the horizontal planes (represented by aa', bb', cc', etc.) bisecting each frame, together with the upper and lower electrodes E and E', constitute equi-spaced, equipotential planes. The associated lines of force are somewhat as indicated. It has been found by electrolytic tank studies that these lines (namely, LM and PQ) have become quite straight at a distance d from the guard strips, where d is approximately $\frac{3}{4}w$. The guard system is thus seen to be a very efficient one, enabling particularly compact chambers to be constructed.

An important further step appears to be the extension of this principle to thimble chambers. Thus imagine Fig. 1 to be rotated about the axis XY. We then obtain a cylindrical chamber, the wall of which can consist of several annular sections separated from one another by very thin washers of insulating material, and possessing a flat circular disk as a collecting electrode. If, in addition, the latter is surrounded by a guard space of appropriate width d, all the lines of force terminating on the collecting electrode will be straight, and the collecting region thereby accurately determined. It has been found that with d equal to one-fifth of the internal diameter of the chamber (the only ratio as yet investigated), the width w of the rings making up the cylindrical wall can be approximately equal to d in value. Fig. 2 shows a section through a practical form of such a chamber, constructed in this case of graphite, and housed in a very thin 'Perspex' shell. 'Terylene' washers, 0·001 in. thick, serve as insulation between the components of the chamber wall. We are also experimenting with chambers of insulating material, the inner surfaces of which are graphited, the cylindrical surface being subdivided according to the above scheme, or screw-cut to provide a steady fall of potential from one end to the other. A very thin and even conducting coating on the cylindrical wall to provide a constant potential gradient may also be possible.

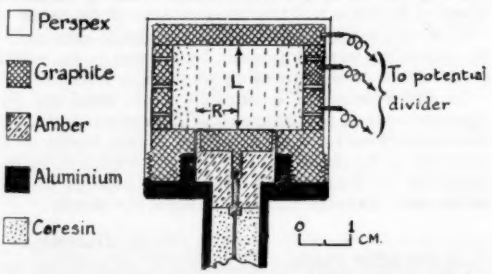


Fig. 2. Section of guarded-field thimble chamber. Note that the top edge of the amber 'cup' holding the collecting electrode is graphite-coated, to minimize the effective gap width. The cup is necessary to avoid charge collection in the gap

Chambers of this type appear to have a number of applications in the study of cavity ionization chambers, and in their use for dosimetric purposes. Among other advantages, the design appears to offer the following:

(i) Geometrical simplicity of the collecting region, enabling its volume to be calculated more easily and more accurately. In particular, the volume depends on knowing two dimensions only: (*a*) the length L of the cylindrical air space; and (*b*) the radius R of the collecting region (inclusive of one-half of the width of the gap surrounding the collecting electrode, which can be made very small indeed, namely, approximately 0·1 mm. or less). Furthermore, the elimination of the usual collecting peg, and the fact that the only solid surfaces bounding the collecting volume are plane ones (on which a very high finish can be attained), remove the uncertainties associated with the exact contours obtaining at the junction of plane and curved surfaces which have been machined.

(ii) Completely uniform electrostatic field throughout the collecting volume, thus eliminating regions of abnormally high field-strength, which might prove troublesome in low-pressure studies.

(iii) Complete symmetry of the electrode system, with a resultant simplification of the problems associated with electron emission and exchange.

(iv) Ease of adjustment of chamber volume; annular wall sections can be added or subtracted at will, without disturbing the configuration of the electrostatic field. The collecting volume is thus strictly proportional to its length.

A fuller account of these new chambers and their design data will be published elsewhere in due course.

L. A. W. KEMP

Physics Laboratory,
London Hospital Research Laboratories,
Ashfield Street, London, E.1.

[1] Taylor, L. S., and Singer, G., *Radiology*, **15**, 637 (1930).
[2] Kemp, L. A. W., and Hall, S. M., *Brit. J. Radiol.*, **27**, No. 316, 219 (1954).

Opaque Spherules in Dust collected at Isolated Sites

A YEAR-LONG programme involving daily collections of atmospheric dust at several widely separated, isolated sites has been undertaken with the object of identifying particles that may be of extra-terrestrial origin. The particles in question are opaque, shiny spherules with diameters less than 10 microns. They appear to be of a nature entirely different from that of the larger spheres abounding in densely populated areas. Their meteoritic nature is suggested by the fact that the rate of fall and the frequency distribu-

tion with size of these particles have been found to be the same at the various stations.

The principal collecting sites were the Smithsonian Astrophysical Observatory's Table Mountain Station above the Mojave Desert of California, a field site of the Geophysical Institute in central Alaska, and the Meteorological Observing Station of the Canadian Meteorological Service at Resolute, North-West Territory, on Cornwallis Island in the Arctic. The collections, begun on July 1, 1955, and completed on June 30, 1956, involved exposing adhesive-covered glass slides to the atmosphere for periods of 24 hr., weather permitting. These slides were scanned under a magnification of 500, making possible identification of particles greater than 3 microns in diameter. Those suspected to be meteoritic were counted and measured after identification by means of tests designed to distinguish them from other types of dust present, involving the use of back lighting, side lighting and polarized light.

The average rate of fall for each station was 1·1 spherules greater than 3 microns in diameter per sq. cm. per day. Assuming that the density of the counted particles is that of iron, this rate corresponds to an annual accretion for the entire Earth of about 10^9 kgm. of these particles.

These results are of interest in relation to the work of Thomsen[1] and of Buddhue[2], who have studied spheres of greater abundance and larger size. No particles of the type they describe were found in the collections from the three principal stations of this programme. Other investigators, notably Crozier[3] and Kizilirmak[4], have studied the magnetic components of dust in the air at their respective institutions.

A promising beginning has been made with an analysis of individual particles by X-ray diffraction techniques. The results of this work will be included in a comprehensive report to be submitted to *Geochimica et Cosmochimica Acta*. A subvention of this project by the Office of Naval Research and the co-operation of the Directors of the collecting stations are gratefully acknowledged.

Paul W. Hodge

Yale University Observatory,
New Haven,
Connecticut.
Aug. 31.

[1] Thomsen, W. J., *Sky and Telescope*, **12**, 147 (1953).
[2] Buddhue, J. D., "Meteoritic Dust" (University of New Mexico Press).
[3] Crozier, W. D., New Mexico Institute of Mining and Technology (personal communication, 1956).
[4] Kizilirmak, Abdullah, *Comm. Faculté d'Ankara*, **6**, Séri A-Fasc. 2, 186 (1954).

Dried Breadfruit

In many of the Pacific territories breadfruit (*Artocarpus altilis* Forst.) constitutes a staple part of the diet. Excepting fermentation procedures, no means of preserving this food in the Pacific islands have previously been described. It has recently been reported[1] that the people of the Reef Islands in the British Solomon Islands Protectorate dry breadfruit for use when it is out of season. It is used also as an item of trade with some of the nearby islands.

The method used for drying is to cook the fresh ripe fruit in the ashes of a fire for an hour. The cooked product is left for a day and then it is peeled, the seeds removed, and it is cut into small pieces which are arranged on a net to a depth of four or five inches. This net is suspended over a smokeless fire and the pieces are turned continuously for about six hours.

The dried breadfruit may be kept for twelve months or more if it is stored in coconut baskets on racks above the kitchen fireplace.

A sample of the dried breadfruit was sent to this laboratory. The composition of the product is given in Table 1 together with results obtained for fresh breadfruit from Western Samoa. It is noted that the calcium content of the dried breadfruit is much higher than would be expected from the fresh breadfruit figure. This may be due to contamination of the product by coral dust during preparation.

Table 1

	Dried (per cent)	Fresh (per cent)
Water	8·0	80·0
Ether extract	2·1	0·5
Crude fibre	4·7	1·2
Total nitrogen	0·63	0·12
Ash	4·2	0·8
Starch (acid hydrolysis)	72·0	12·0
Calcium	0·44	0·03
Phosphorus	0·13	0·03

We wish to thank Mr. J. L. O. Tedder, District Commissioner, Eastern District, British Solomon Islands Protectorate, for supplying us with a sample of dried breadfruit for analysis.

F. E. Peters
Pamela A. Wills

South Pacific Commission,
Noumea,
New Caledonia.
Sept. 20.

[1] Tedder, J. L. O., *South Pacific Comm. Quart. Bull.*, **6**, No. 3, 21 (1956).

"Fluorimetry"

In a recent communication to *Nature*[1] there appears an article entitled "Determination of Intermediary Metabolites by Enzymic Fluorimetry". May I suggest that the term *fluorimetry* is quite inappropriate in the sense in which it is employed in the article, namely, that of the measurement of *fluorescent light*.

As the words 'fluor-spar' and 'hydrofluoric' show, *fluor* is well established as an abbreviation of *fluorine*. Surely, then, fluorimetry, in a chemical context, can scarcely be interpreted otherwise than as meaning *assay of fluorine*, not the *measurement of fluorescence*.

It would seem unfortunate if the usage here called in question were followed by others; it would certainly be most confusing to foreign workers.

In the absence of a suitable *single* word for the measurement of the intensity of fluorescent light, the determinations referred to in the article would seem properly to be described as 'by fluorescence measurement' or 'by fluorescence estimation'—longer though these are. Brevity may be bought too dearly.

V. H. Blackman

17 Berkeley Place,
London, S.W.19.
Sept. 25.

[1] Greengard, P., *Nature*, **178**, 632 (1956).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, December 3

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO and MEASUREMENT SECTIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal Evening on "Electronics and Automation—The Use of Nucleonic Devices". Talk by Dr. Denis Taylor.

ROYAL METEOROLOGICAL SOCIETY (in the Conference Hall, County Hall, London, S.E.1), at 5.30 p.m.—Mr. N. Bradbury: "Aviation Meteorology".* (Lecture for Sixth-form Scholars.)

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Sir Charles S. Lillicrap: "The Submarine: Past, Present and Future".

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. J. D. Roberts (California Institute of Technology): "Nuclear Magnetic Resonance Spectroscopy and Applications to Organic Chemistry".* (Further lecture on December 5.)

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the LONDON SECTION of the SOCIETY OF CHEMICAL INDUSTRY, at 14–16 Belgrave Square, London, S.W.1), at 6.30 p.m.—Prof. P. M. S. Blackett, F.R.S.: "Elementary Particles of Nature".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—General Sir James Marshall-Cornwall: "Military Geography of Wales".

Tuesday, December 4

BRITISH ASSOCIATION FOR COMMERCIAL AND INDUSTRIAL EDUCATION (at the Royal Festival Hall, London, S.E.1), at 10.30 a.m.—Conference on "Automation, Education and Training".

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY (in the Main Chemistry Lecture Theatre, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Prof. B. G. Peters: "Parasitology at Imperial College" (Inaugural Lecture).

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. R. P. Fraser: "High Intensity Combustion in Chemical Engineering".

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Mr. C. L. Champion, Mr. R. J. R. Hancock and Mr. W. Woolfson: "The Design and Construction of a Laboratory for Research in Underwater Ballistics".

Wednesday, December 5

IRON AND STEEL INSTITUTE, IRON AND STEEL ENGINEERS GROUP (at 4 Grosvenor Gardens, London, S.W.1), at 10.30 a.m.—Mr. F. J. Potter and Mr. L. Duffy: "Blowers for Use in Iron and Steel Works"; at 2 p.m.—Mr. V. Barnett: "Gas and Air Compressors".

CIBA FOUNDATION (in the Large Hall, Friends House, Euston Road, London, N.W.1), at 5 p.m.—Prof. R. B. Woodward (Harvard): "Recent Advances in the Chemistry of Natural Products".

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. P. W. Cooke: "The Hydraulics of Drilling Mud Flow".

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. P. L. M. Rockwell: "Air Navigation".

SOCIETY FOR ANALYTICAL CHEMISTRY (in the Meeting Room of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Meeting on "Trade Effluents".

Thursday, December 6

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at the Royal School of Mines, South Kensington, London, S.W.7), at 4 p.m.—Annual General Meeting, followed by Mr. H. J. Goldsmid: "Thermo-electric Cooling".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Wilfrid Le Gros Clark, F.R.S.: "Enquiries into the Anatomical Basis of Olfactory Discrimination" (Ferrier Lecture).

INSTITUTION OF NAVAL ARCHITECTS (in the Weir Lecture Hall, 10 Upper Belgrave Street, London, S.W.1), at 4.45 p.m.—Mr. A. Augustin Normand and Mr. Bartholon: "Some Problems in Design and Use of Free Piston Gas Generators on board Ships".

CHADWICK TRUST (in the Lecture Theatre, Wright-Fleming Institute, St. Mary's Hospital, Paddington, London, W.2), at 5 p.m.—Dr. J. N. Morris: "Clinical and Community Medicine".* (Malcolm Morris Memorial Lecture.)

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Dr. J. E. Richardson: "Technical Education in Nigeria".

INSTITUTE OF REFRIGERATION (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1), at 5.30 p.m.—Miss B. Shilling: "Cooling Problems in High Speed Military Aircraft".

SIR THOMAS MIDDLETON MEMORIAL TRUST (in the Auditorium, The Wellcome Building, 183 Euston Road, London, N.W.1), at 5.30 p.m.—Prof. V. B. Wigglesworth, F.R.S.: "Insects and the Farmer" (Fourth Middleton Memorial Lecture).

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Meeting on "New and Revised Test Methods".

INSTITUTE OF METALS, LONDON LOCAL SECTION (joint meeting with the London Branch of the Institute of British Foundrymen at 17 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. E. F. Emley: "The Founding of Magnesium".

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "The Sphere and Duties of the Industrial Education Officer".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the BATTERSEA POLYTECHNIC CHEMICAL SOCIETY, at the Battersea Polytechnic, Battersea Park Road, London, S.W.11), at 7 p.m.—Dr. C. H. Bamford: "Properties and Configuration of Large Molecules".

BRITISH GLACIOLOGICAL SOCIETY (at Bedford College, Regent's Park, London, N.W.1), at 7.30 p.m.—Annual General Meeting, followed by Mr. G. A. Kellaway: "Frost Heaving and Thermokarst Phenomena in Perennially Frozen Regions".

Thursday, December 6—Friday, December 7

BRITISH INSTITUTE OF RADIOLOGY, incorporated with the RÖNTGEN SOCIETY (at Caxton Hall, Westminster, London, S.W.1)—Annual Congress and Exhibition.

Friday, December 7

BRITISH SOCIETY OF RHEOLOGY (at the Institute of Physics, 47 Belgrave Square, London, S.W.1), at 10 a.m.—Meeting on "Rheological Control of Industrial Processes".

ROYAL SOCIETY OF MEDICINE, OTOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 10.30 a.m.—Discussion on "Noise and its Effects". Opening speakers: Dr. J. D. Hood, Prof. W. Burns, Mr. D. E. Broadbent and Dr. H. F. Schuknecht (Detroit).

ASSOCIATION OF APPLIED BIOLOGISTS (in the Lecture Hall of the Royal Entomological Society, 41 Queen's Gate, London, S.W.7), at 10.50 a.m.—Scientific Papers.

PHYSICAL SOCIETY, ACOUSTICS GROUP (at Imperial College, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Mr. H. J. Pain: "Shock Waves in Gases".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. A. D. S. Carter and Mr. D. A. Kilpatrick: "The Self Excited Vibration of Axial Flow Compressor Blades".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. R. V. Moore: "The Development of Nuclear Power".* (Ninth of ten University Extension Lectures on "Technology and Industry". Further lecture on December 14.)

BRITISH PSYCHOLOGICAL SOCIETY, EDUCATION SECTION (at the University of London Institute of Education, Malet Street, London, W.C.1), at 6.45 p.m.—Dr. Alice W. Heim: "Some Preliminary Experiments on a Test of Concept-Formation".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Mr. A. E. T. Neale: "Newer Applications of Fine Chemicals in the Rubber Industry".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir George Thomson, F.R.S.: "J. J. Thomson".

Saturday, December 8

BRITISH MYCOLOGICAL SOCIETY (at the Linnean Society of London, Burlington House, Piccadilly, London, W.1), at 12 noon—Annual General Meeting.

BRITISH PSYCHOLOGICAL SOCIETY (in the Psychology Department, Birkbeck College, Malet Street, London, W.C.1), at 2.30 p.m.—Prof. Frank A. Geldard (University of Virginia): "Tactile Literacy".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. John Usborne: "Watching North American Birds".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

BIOCHEMIST (with at least three years' experience in the procedures of biochemistry or chemical pathology, and a higher degree in biochemistry or physiological chemistry such as the M.Sc., Ph.D., or equivalent) at St. Kevin's Hospital, Dublin—The Secretary, Local Appointments Commission, 45 Upper O'Connell Street, Dublin (December 7).

ENTOMOLOGIST (with a first- or second-class honours degree or equivalent and interested in applied entomological research, and preferably with both field and laboratory experience) IN THE TECHNOLOGICAL IRRADIATION GROUP of the Isotope Division—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting Ref. 667/34 (December 10).

PRINCIPAL (with high academic qualifications and wide experience, preferably including industrial, research, and teaching experience) OF THE ROYAL TECHNICAL COLLEGE, Salford—The Director of Education, Education Office, Chapel Street, Salford (December 12).

LECTURER IN ELECTRICAL ENGINEERING—The Registrar, University College, Singleton Park, Swansea (December 15).

LECTURER, Grade I (with high academic qualifications, and preferably industrial experience), to take charge of the Sub-Department of Malting and Brewing in the Department of Biochemistry—The Registrar, The University, Birmingham (December 17).

CHAIR OF THERAPEUTICS AND PHARMACOLOGY—The Secretary, The Queen's University, Belfast (December 20).

ASSISTANT LECTURER IN CHEMISTRY at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 31).

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 31).

RESEARCH ASSISTANT IN THE DEPARTMENT OF CHEMISTRY, for work on the fundamental chemistry of grass conservation—The Secretary, The University, Edinburgh (December 31).

SENIOR LECTURER/LECTURER IN MATHEMATICS; LECTURER IN PHYSICS; and a LECTURER IN ZOOLOGY at Kumasi College of Technology, Gold Coast—The Secretary, Advisory Committee on Colonial Colleges 1 Woburn Square, London, W.C.1 (December 31).

LECTURER or ASSISTANT LECTURER IN MATHEMATICAL STATISTICS—The Registrar, The University, Manchester (January 1).

LECTURER IN EXPERIMENTAL PHYSICS—The Registrar, The University, Liverpool (January 2).

LECTURER IN BIOCHEMISTRY at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

ASSISTANT BIOCHEMIST (with a B.Sc. in chemistry or biochemistry, or the A.R.I.C.) in the Group Laboratory, Crumpsall Hospital—The Hospital Administrator, Crumpsall Hospital, Manchester 8.

ASSISTANT CHEMIST (with a degree in chemistry, agricultural chemistry or A.R.I.C.), for analytical work on crops and soils—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting Ref. 1052/9.

ASSISTANT LECTURER (graduate, with experience in teaching or in industry) IN THE SCHOOL OF PHYSICS—The Registrar, College of Technology and Commerce, Leicester.

ASSISTANT LECTURER (with a university degree in electrical engineering and practical experience in the electrical industry) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

BIOCHEMIST (with a science degree of a recognized university and special experience in medical biochemistry) with the Ministry of Health, Gold Coast Local Civil Service, to take charge of the Biochemistry Division of the Medical Research Institute—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/13/042.

DEMONSTRATOR (preferably with a university degree or professional qualification) IN THE DEPARTMENT OF AIRCRAFT ELECTRICAL ENGINEERING, to take charge of the everyday running and maintenance of a teaching and research laboratory devoted to work in the telecommunications, radio navigational, radar and microwave fields—The Recorder, College of Aeronautics, Cranfield, Bletchley, Bucks, quoting Ref. ER/D.

LABORATORY TECHNICIAN (with considerable experience in virology and preferably also in tissue culture work)—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey.

LABORATORY TECHNICIAN (with some training in bacteriological technique and preferably with Inter. I.M.L.T.)—The Secretary, Royal Veterinary College, Royal College Street, London, N.W.1.

LECTURER (Grade II) IN THE DEPARTMENT OF CHEMICAL ENGINEERING—The Registrar, The University, Birmingham 15 (January 1).

LECTURER (with an honours degree or equivalent, and preferably some industrial or teaching experience) IN MATHEMATICS at Coventry Technical College—The Director of Education, New Council Offices, Coventry.

RESEARCH ASSISTANT (with an honours degree in biochemistry or physiology, or a B.Sc. (Pharmacy), with some research experience) IN THE EXPERIMENTAL RADIATION THERAPEUTICS DEPARTMENT—The Administrative Officer, Christie Hospital and Holt Radium Institute, Manchester 20.

SENIOR SCIENTIFIC OFFICERS/SCIENTIFIC OFFICERS (with a first- or second-class honours degree in physics or electrical engineering, together with experience of conducting independent research in suitable aspects of electronics), to carry out original research into problems arising in the application of electronics to nuclear physics, and to develop new electronic techniques and methods of use in nuclear physics research—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 1325/34.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Metallurgical Reviews. Vol. 1, Part 1, 1956. To be published quarterly. Pp. 156. Annual Subscription rates: Members of the Institute of Metals, 32*s.* 6*d.* (5 dollars); Non-members, 42*s.* (6.50 dollars). (London: Institute of Metals, 1956.) [189

British Museum (Natural History). Ruwenzori Expedition 1934–35. Vol. 1, No. 7: Tipulidae. By Charles P. Alexander. Pp. 129–380+plates 27 and 28. (London: British Museum (Natural History), 1956.) 60*s.* [189

Aero Research Technical Notes. Bulletin No. 164: Honeycomb Sandwich Flooring for Aircraft. Pp. 6. (Duxford: Aero Research Limited, 1956.) [189

Institute of Navigation. Report of the Council, 1955–56. Pp. 16. (London: Institute of Navigation, 1956.) [189

British Broadcasting Corporation: Engineering Division. Monograph No. 8: An Automatic Integrator for Determining the Mean Spherical Response of Loudspeakers and Microphones. By A. Gee and D. E. L. Shorter. Pp. 16. (London: British Broadcasting Corporation, 1956.) 5*s* [189

Memoirs of the Royal Astronomical Society. Vol. 67, Part 4: A Survey of Southern HII Regions. By Colin S. Gum. Pp. 155–178+12 plates. (London: Royal Astronomical Society, 1956.) 32*s.* [189

A Short Course in Radiological Protection. By the Health Physics Division and the Isotope School, A.E.R.E. Edited by R. J. Sherwood and H. J. Dunster. Pp. 118. (London: H.M. Stationery Office, 1956.) 13*s.* 3*d.* net. [189

Other Countries

Union of South Africa: Department of Agriculture. Science Bulletin No. 359: Fertilizer and Irrigation Experiments at the Upington Agricultural Research Station, 1942–1952. By C. P. Naude, T. P. Pretorius and I. J. Nothling. Pp. ii+42. (Pretoria: Government Printer, 1956.) 6*d.* [249

National Museum, Bloemfontein. Research, Vol. 1, Part 9: The Macrolithic Culture of Florisbad. By A. J. D. Meiring. Pp. ii+205–238 (5 plates). (Bloemfontein: National Museum, 1956.) [249

Journal of Technology. Vol 1, No. 1 (June, 1956). Pp. 104. (A half-yearly publication of original contributions in Science and Technology.) Subscription rates: India, Rs. 10; Elsewhere, 16*s.*; 2.50 dollars. (Howrah: Bengal Engineering College, 1956.) [249

Institut pour L'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. Rapport Annuel Exercice 1955. Pp. 236. (Bruxelles: Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1956.) [249

Indo-Pacific Fisheries Council. Special Publications. No. 3: Economic Marine Algae of Tropical South and East Asia and their Utilization. By J. S. Zaneveld. Pp. ii+55. (Bangkok: FAO Regional Office for Asia and the Far East, 1955.) [249

United States Department of Agriculture. Circular No. 979: Dryland Crop-Rotation and Tillage Experiments at the Colby (Kans.) Branch Experiment Station. By J. B. Kuska and O. R. Matthews. Pp. ii+87. (Washington, D.C.: Government Printing Office, 1956.) 35 cents. [249

National Academy of Sciences—National Research Council. Nuclear Science Series—Report No. 18: Basic Mechanisms in Radiobiology 4—Cellular Aspects. Edited by Harvey M. Patt and E. L. Powers. (Proceedings of an Informal Conference, Bear Mountain, New York, May 12–14, 1955.) Pp. vii+190. (Publication 450.) (Washington, D.C.: National Academy of Sciences—National Research Council, 1956.) [249

Indian Journal of the History of Medicine. Vol. 1, No. 1 (June 1956). Pp. iv+69. Published twice a year in June and December. Subscription rates: India Rs. 8; Outside India, the foreign currency equivalent to Rs. 12. (Madras: Indian Association of the History of Medicine, 1956.) [249

United States Department of the Interior: Geological Survey. Water-Supply Paper 1280: Surface Water Supply of the United States, 1953. Part 6-B: Missouri River Basin below Sioux City, Iowa. Prepared under the direction of J. V. B. Wells. Pp. x+460. 1.50 dollars. Water-Supply Paper 1288: Surface Water Supply of the United States, 1953. Part 14: Pacific Slope Basins in Oregon and Lower Columbia River Basin. Prepared under the direction of J. V. B. Wells. Pp. viii+302. 1 dollar. Water-Supply Paper 1358: Geology and Ground-Water Resources of Buffalo County and Adjacent Areas, Nebraska. By R. L. Schreurs. With a section on the Chemical Quality of the Ground Water by Frank H. Rainwater. Pp. v+175+5 plates. n.p. Water-Supply Paper 1360-A: Reservoirs in the United States. By Nathan O. Thomas and G. Earl Haebeck, Jr. Pp. v+99+1 plate. 75 cents. Water-Supply Paper 1359: Geology and Ground-Water Resources of the Orestonsburg Quadrangle, Kentucky. By William E. Price, Jr. Pp. v+140+4 plates. 1 dollar. Bulletin 965-D: Birth and Development of Paricutin Volcano, Mexico. By William F. Foshag and Jenaro Gonzalez R. Pp. vi+355–490+plates 12–51. n.p. Bulletin 1009-K: Uranium-Bearing Nickel-Cobalt-Native Silver Deposits, Black Hawk District, Grant County, New Mexico. By Elliot Gillerman and Donald H. Whitebread. Pp. iv+283–312+plates 14–16. 65 cents. (Washington, D.C.: Government Printing Office, 1956.) [249

The Time Concept in Special Relativity. By Prof. José Alvarez López. Pp. iv+32. (Cordoba: Edicion Scientia, 1956.) [249

Schweizerische Medizinische Wochenschrift, Beiheft zu Nr. 37: Herrn Prof. Dr. Fritz Verzar, zum 70. Geburtstag, 18 September 1956. Pp. ii+1041–1086. (Basel: Benno Schwabe and Co., 1956.) [249

Inter-American Tropical Tuna Commission. Bulletin. Vol. 1, No. 5: Observations on the Taxonomy, Biology, and Ecology of the Engraulid and Clupeid Fishes in the Gulf of Nicoya, Costa Rica. By Clifford L. Peterson. Pp. ii+139–280. Vol. 1, No. 6: Studies of the Sexual Development and Spawning of Yellowfin Tuna (*Neothunnus Macropterix*) and Skip-Jack (*Katsuwonus Pelamis*) in Three Areas of the Eastern Pacific Ocean, by Examination of Gonads. Pp. 281–350. (La Jolla, Calif.: Inter-American Tropical Tuna Commission, 1956.) [249

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Carte des Sols et de la Végétation du Congo Belge et du Ruanda-Urundi 7. Bugesera-Mayaga (Ruanda). A, B et C. Notice explicative de la Carte des Sols et de la Végétation. Par R. Frankart et L. Liben Pp. 58+3 cartes. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1956.) 150 francs. [249

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., Crown House, 143–147 Regent Street, London, W.1
Telephone Number: Regent 3891

All rights reserved. Registered as a newspaper at the General Post Office